NOVEMBER 9, 1959

PRICE 50 CENTS

Product Engineering

McGRAW-HILL WEEKLY OF DE D DEVELOPMENT

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see page 5

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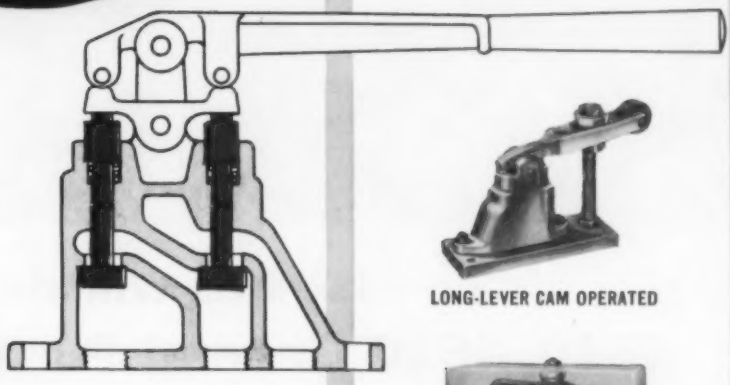

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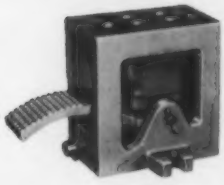

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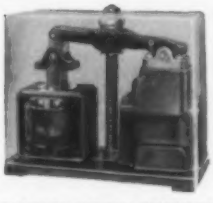

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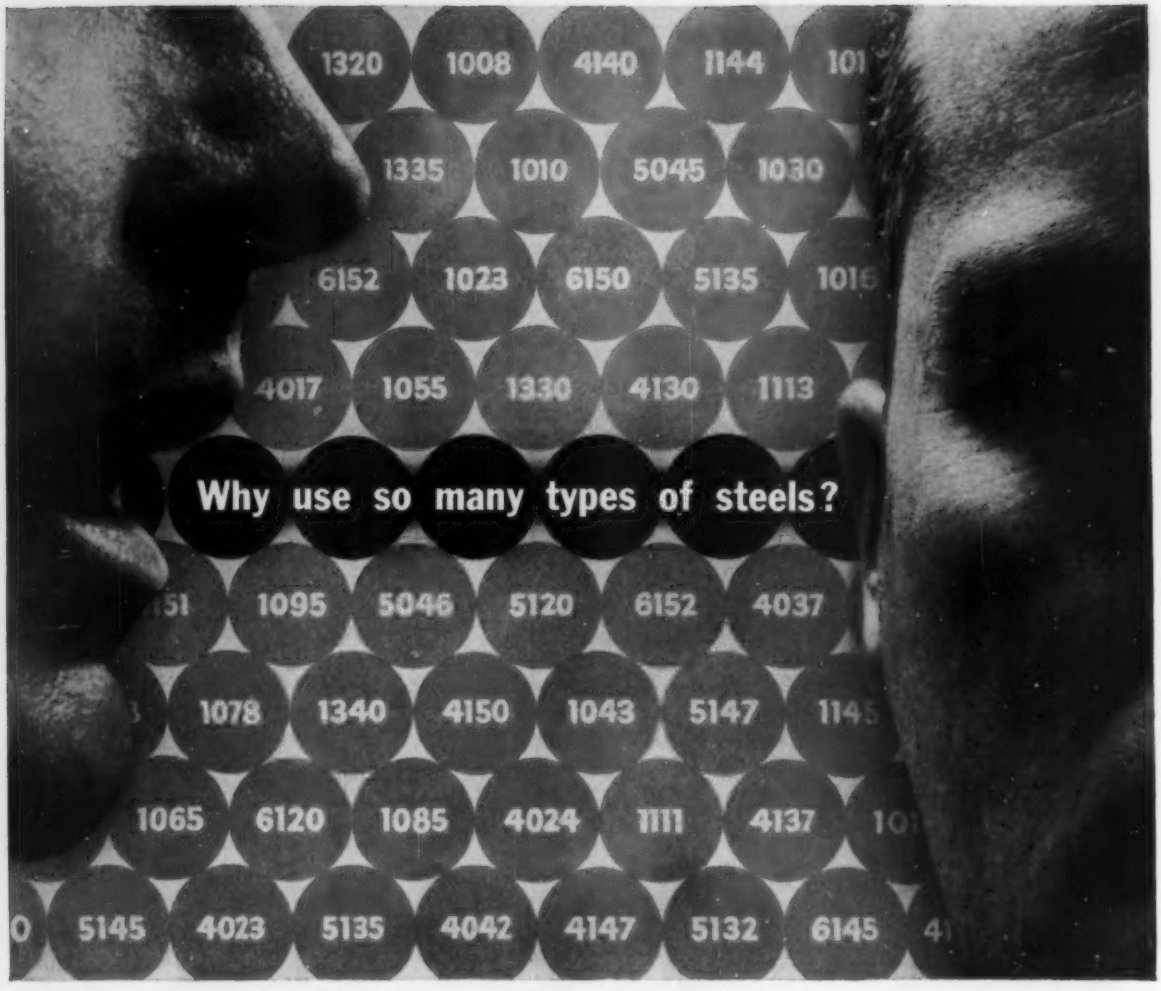

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DESIGN issue

November 9, 1959 Vol. 30, No. 46

FEATURED:

DEPARTMENTS:

INTERESTING TO NOTE 5
DEVELOPMENTS TO WATCH 35
THE ENGINEERING WEEK 37
COMING EVENTS 42
HORIZONS 69
PRODUCT DESIGNS 77
SIGNIFICANT COMPONENTS 105
CATALOGS AND BULLETINS 127
CURRENT REPRINTS 147
TANGENTS 154
DESIGN ABSTRACTS 165
NEW BOOKS 169
ADVERTISERS INDEX 183
READER SERVICE CARDS 187

SIMULATORS MEASURE ABRASION RESISTANCE
Standard machines test candidates quickly.....D Gardner 70

This simple abrader was custom-built for a special job.....S Bortas 72

REINFORCED PLASTICS FOR BETTER SPRINGS . . . L A Heggernes, 3M Company
Leaf springs from these epoxies can outperform steel..... 74

ECONOMICAL MALLEABLE-IRON CASTINGS . . . H L Kee, assistant editor
8 ways to get the most out of post-forming techniques..... 82

HYDRAULIC SERVOVALVES . . . W Ernst, Commonwealth Engineering
How these valves work and factors to consider when applying them.... 84

LATEST TREND IN BOLT THREADS . . . R Sproat, Standard Pressed Steel Co
Root radius gets larger—75% threads now, 55% threads a possibility.. 89

HOW THE SHADED-POLE MOTOR PERFORMS . . . J E Truba, R N Webber, GE
Comparative performance data shows increased efficiency, low heat-losses 92

ARCS SUBTENDED BY SMALL ANGLES . . . M A Donohue, Gleason Works
For various angles and radii—calculated on a "650" computer..... 98

FIELDS OF INTEREST REPRESENTED IN DEPARTMENTS:

MATERIALS: **Faster photographic films** are electrically sensitive..... 36
Non-woven, low-density-filter material based on rayon fiber..... 105

MECHANICAL: **Needle valve seals itself,** acts as its own seal..... 35
Fatigue cracking may not be a serious design hazard..... 36
Constant-volume regulator for air or gas..... 105
Fasteners have offset recess to increase shoulder width..... 105
Oil-seal wear sleeve has rubber inside, polished metal outside..... 105

ELECTRICAL: **Ac solenoid for 400 cycles** operates at 600 F..... 36
Fractional hp motor gets a centrifugal clutch..... 36

PRODUCT DESIGN: **Jeeps get star billing** at Frankfurt auto show..... 37
Rugged TV minimizes maintenance time..... 77
Simplified tape control has no electronics..... 78
Radial pump has 14 identical pistons for simplicity..... 80
Rotary blower eliminates seals in supercharger..... 81

GENERAL: **Science against society**—a conflict of interests..... 5
Old player piano forecasts punched paper tape..... 7
Engineers air views on college studies..... 39

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Interesting to Note . . .

Printed Circuits

Reams of paper have been filled with discussions of the relative merits of wired and printed circuits (for an example, *PE*—Sept 7, p 42). Motorola liked the manufacturing savings but encountered difficulties with connections that peeled off and circuit boards that warped or couldn't support the weight of all TV components. Some boards were too thin to withstand the not-always-friendly ministrations of the TV serviceman. But recently (*PE*—July 27 '59, p 9), Motorola came up with the answer, a heavy plated circuit on a stiff fiberglass-reinforced board. To withstand the serviceman and part weight, the board has a metal reinforcing on its front edge; to ease circuit tracing it has the conductors color-coded in accordance with RETMA specs, with the circuits of one side repeated on the other side in black.

Pull four simple clips and then three 12-wire connector bars separate as a spring-loaded lever ejects the board. Or loosen four screws and the whole chassis can be replaced. The PLAcir boards (for plated circuitry) on our cover are held by Garth J. Heisig, director, TV Engineering: two boards with components applied are on the table; and Karl H. Horn, chief engineer, TV Engineering Division, holds the completed TV set. Behind them is the line on which the 17-in. portable—first to use the new board—is assembled.

Science Against Society

In the past, men of science were regarded as revolutionaries. This was because of the very nature of their work: anyone who dared break away from the norm by either thought or deed was considered a danger to the entire social order. Socrates, the Athenian philosopher, was one of the first great thinkers to believe and even teach concepts that violated the accepted word. His tragic end was but a preview of what other freethinkers could look forward to. Fear of change has been the greatest cause of society's hostility toward the deviator.

In early days, religion was against the inquisitive investigator. Galileo, for example, was condemned in 1615 because he believed and preached the Copernican theory of astronomy. Because astronomy infringed upon religion, as did most sciences of the

CONTINUED ON PAGE 7

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Interesting to Note . . . CONTINUED

17th century, Galileo received a semiofficial warning: not to tinker with theology but limit himself to "physical" reasoning. He was later admonished by Pope Paul V and forbidden to "hold, teach or defend" the condemned doctrine. Galileo promised to obey this injunction, but in February, 1632, he published his famous, ill-starred work, *Dialago dei due Massinmi Sistemi del Mondo*. The book was banned by the Church in August; in October Galileo was called to Rome to face the Inquisition. It was the following year, however, before his health allowed him to make the trip. Galileo was forced to recant, then was sentenced by the tribunal to incarceration.

Religion wasn't the only barrier to the inquiring mind. Politics entered the picture during the 18th and 19th centuries. When a scientist published, he was often accused of being a revolutionist by the people in power and, conversely, was called pro-government by the opposition. Since, by the very nature of the creative mind, change is essential, the majority of scientists between 1700 and 1900 were against the stagnant political forces in power. A few great scientists lost their lives for political reasons before they ever reached the age of 30. Gascoigne, the first astronomer to accurately measure celestial angles, died in a civil war before his 25th birthday.

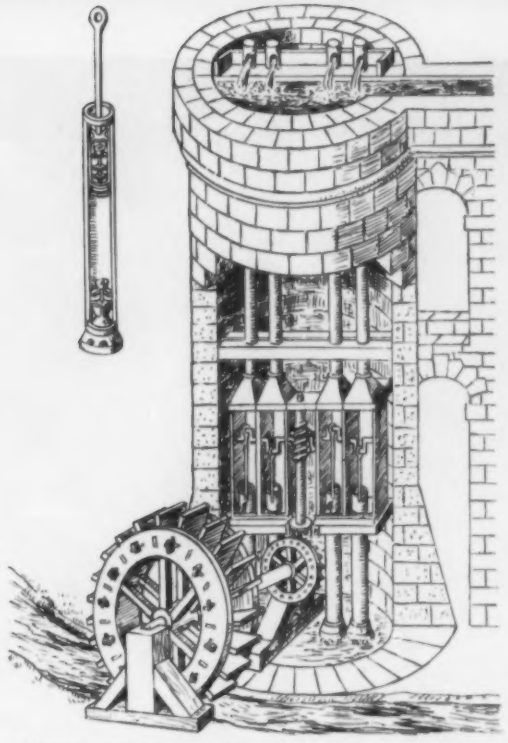
One of the great French mathematicians, Evariste Galois, was killed in a duel rigged against him for political reasons. Although he was only 20 when he died, Galois left his mark with the series of papers he wrote on mathematical theories. Even his early schooling was tragic. As a genius he had no friends and soon alienated his teachers who resented his "ambition and originality." At one time he became interested in angles and arcs (p 98). He picked up a geometry book by Legendre (usually a two year course) and mastered it in an evening.

When he was 17 his first paper was published—on continued fractions. Soon after, young Galois received a series of setbacks. He wrote a paper on his fundamental studies for the French Academy of Sciences, but the manuscript was lost. Two years later he wrote three papers presenting new discoveries in the theory of algebraic equations for competition given by the Academy of Sciences. Galois would have won first prize, but death suddenly struck the examiner who took them for study. The papers were lost. On the night before Galois died, he did his last writing. Scientists know these today as the Galois Group, Galois Field, and Galois Theory.

Get the Water Out

Removing water from early mines was often such a problem that good mines actually had to be abandoned. Rope-and-bucket bailing was the rule, but not too efficient when shafts were crooked. During the Middle Ages continuous chainbelt with large rags stuck between the links acted as a continuous sponge, but it also was inefficient.

The importance of draining water from mines spurred the development of pumps (p 80). Simple suction pumps made from hollow tree trunks began appearing around the 16th century. Then Leonardo da Vinci sketched several valves which improved pump design.



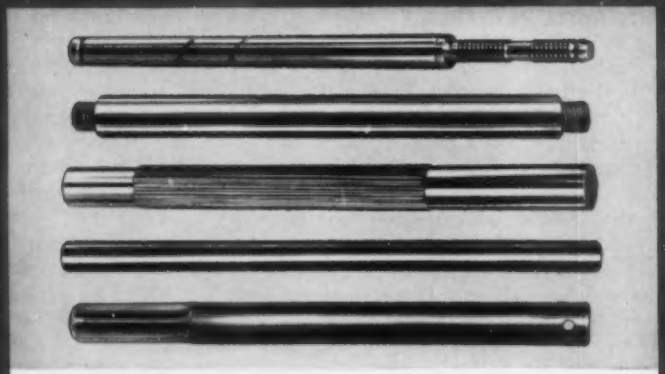
Although early pumps depended greatly on the type of power available, suction pumps were predominant. It is interesting that the operation of these pumps were fully understood a full century before Galileo, Torricelli and Pascal published scientific analysis of the vacuum. During the mid-1500's Agastino Ramelli designed a quadruple suction pump powered by a water wheel. Its purpose was to convey water from a stream to a cistern that served an aqueduct. Note the types of gearing Ramelli used on a pump—one of the most advanced designs of its day.

Piano Roll Blues

When Al Jolson appeared in the first talking picture, show business began dressing for the funeral of vaudeville. The old comedy and dance teams would soon be out of work while only a few of the serious actors could hope to get jobs in the new entertainment medium. Who could dream that in a matter of years vaudeville would be back again with a new name, television. However, the advent of movies, television, and phonograph records dealt a strong blow to another of the entertainment fields, the home piano. In 1904 the US had 249 factories employing 23,000 making pianos; in 1954 only 27 establishments were left.

In principle, the old fashioned player piano dated back to Joseph Jacquard, inventor of the silk weaving loom. It was Jacquard who, in 1802, used perforated cardboard to "program" a loom. 40 years later, another Frenchman, Seytre, used this principle to release and guide the keys on a piano. In America more refinements were made so that a role of hard paper not only operated the keys, but was able to shade the tempo and intensity of the music. Although player pianos are a rarity today, machines operated by punched paper or tape are now commonplace. The machine described on page 78 uses a paper half the size of one used on a player piano, and it controls up to 600 operations on a single machine.

—Benedict A Leerburger Jr



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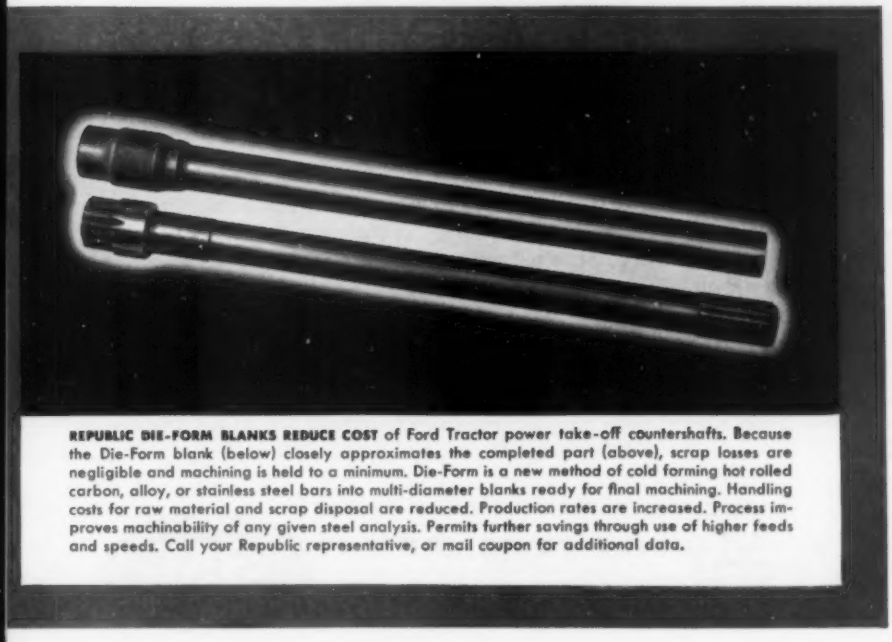

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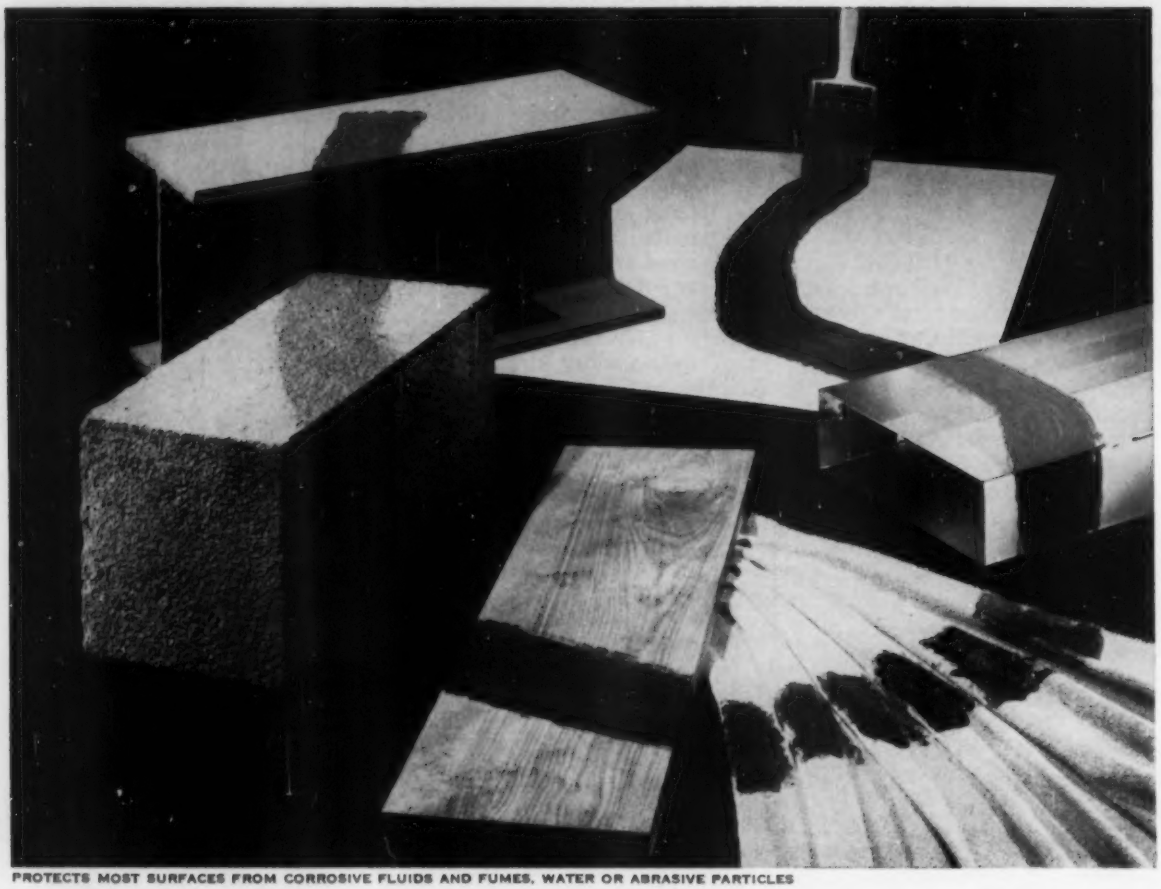

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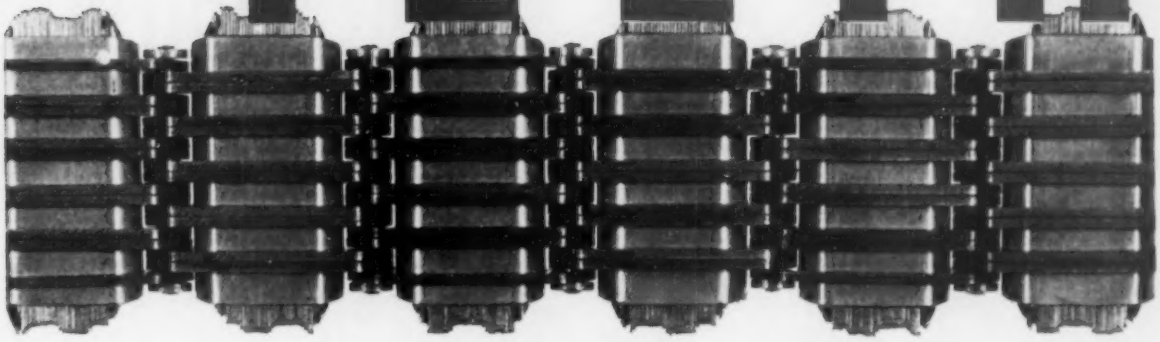

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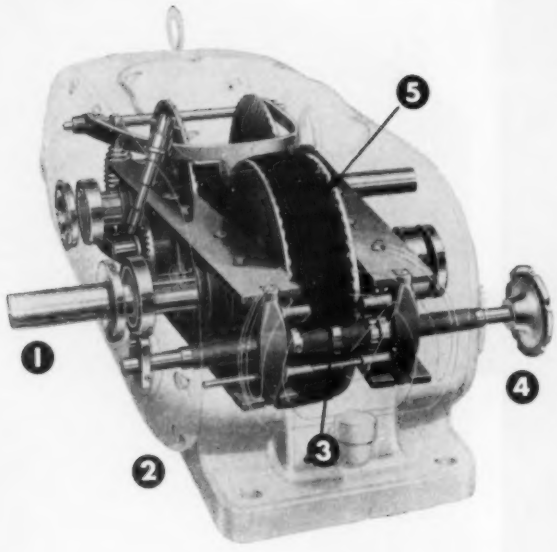


Get the positive, accurate control that only LINK-BELT's chain-driven P.I.V. can deliver

Yes, you put teeth into your speed changing jobs because Link-Belt P.I.V.—unlike other variable speed drives—utilizes an exclusive metal, self-tooth-forming chain.

Here's how it works! P.I.V. chain consists of a series of overlapping steel links. The links contain packs of slats which are free to move from side to side, singly or collectively, to serve as teeth. The chain meshes with radially grooved wheels, which are cut to a constant depth towards the wheel periphery. Beveled sides of the grooves offer gripping areas . . . provide a positive, nonslip contact at any speed, under all loads.

Makes changing speed simple too! A turn of the control screw simultaneously varies the effective diameters of the conically shaped wheels—closing one set, spreading the other. At the same time, the self-tooth-forming chain automatically adjusts to provide desired ratio between the input and output shafts.

BOOK 2274—Your Link-Belt office has Book 2274 on P.I.V. drives from ½ to 25 hp. Refer to the yellow pages of your local phone directory under Power Transmission Equipment.

(1) You can get minute speed changes and maintain them accurately while operating under full load.

(2) All-metal, totally enclosed—unaffected by atmospheric conditions. All vital operating parts splash-lubricated from a common housing reservoir.

(3) Easy-view speed indicator facilitates speed selection and adjustments to meet all requirements.

(4) An infinite number of positive, stepless speed adjustments may be made with manual, electric, pneumatic or hydraulic controls.

(5) Self-tooth-forming chain is made from a series of overlapping steel links. Links contain packs of hardened steel laminations or slats (shown above). Slats grip toothed wheels positively without slippage —give the speed you need at any setting.

15,242

LINK-BELT COMPANY: Executive Offices, Prudential Plaza, Chicago 1. To serve Industry There Are Link-Belt Plants, Sales Offices and Stock Carrying Distributors in All Principal Cities. Export Office, New York 7; Australia, Marrickville (Sydney); Brazil, Sao Paulo; Canada, Scarboro (Toronto 13); South Africa, Springs. Representatives Throughout the World.

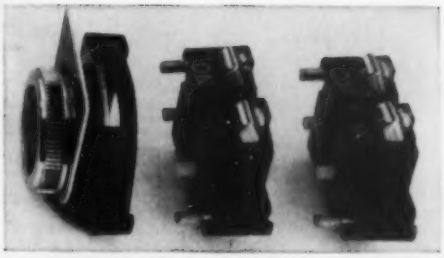
P.I.V. LINK-BELT
VARIABLE SPEED DRIVE

CIRCLE 11 ON READER SERVICE CARD 11

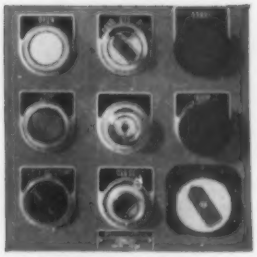
YELLOW BLUE GREEN GRAY BROWN BLACK

WESTINGHOUSE FLUSH PUSHBUTTON

puts the finger on color coding with snap-on color caps !



Shallow contact blocks stack for multiple control circuits. Angled terminals are easy to get at with a screwdriver, even when blocks are stacked.



Available in a full range of operator designs.

HERE'S PRACTICAL PUSHBUTTON COLOR CODING—the economical Westinghouse way. Snap-on color caps let you change colors *without changing buttons.* Simply remove the clamp ring and color caps snap off easily and can be replaced in a matter of seconds.

Simplified color coding is but one of the many pluses for new Westinghouse flush pushbuttons. Thin operator and shallow contact blocks make this pushbutton *thinnest overall.* Contact blocks stack for control of multiple operations, another space-saving feature.

Flush pushbuttons are oiltite, of course. And they meet exacting machine tool and control panel requirements. Available in a full range of operator designs.

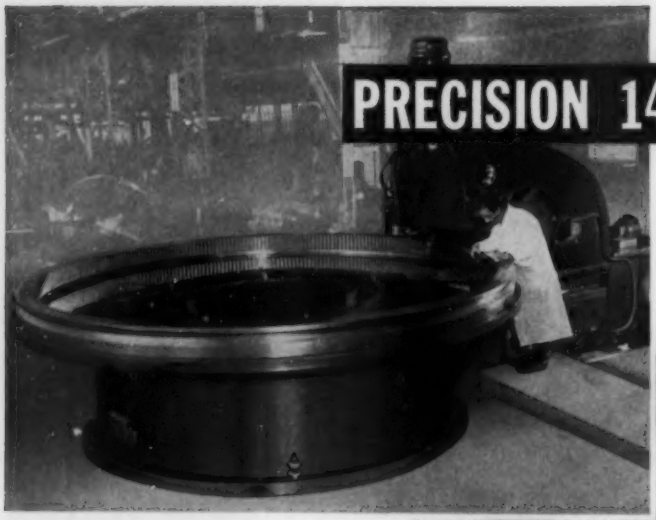
Regardless of your pushbutton requirements, order with confidence from industry's most extensive line. Contact your nearby Westinghouse sales office or distributor, or write: Westinghouse Electric Corporation, Standard Control Division, Beaver, Pa.

J-30304

YOU CAN BE SURE...IF IT'S **Westinghouse**

WATCH "WESTINGHOUSE LUCILLE BALL-DESI ARNAZ SHOWS" CBS TV FRIDAYS

CIRCLE 13 ON READER SERVICE CARD



PRECISION 141″ INTERNAL GEAR

by PHILADELPHIA

. . . WILL REVOLVE THIS 70 TON AIR-SEARCH RADAR ANTENNA ASSEMBLY ➡

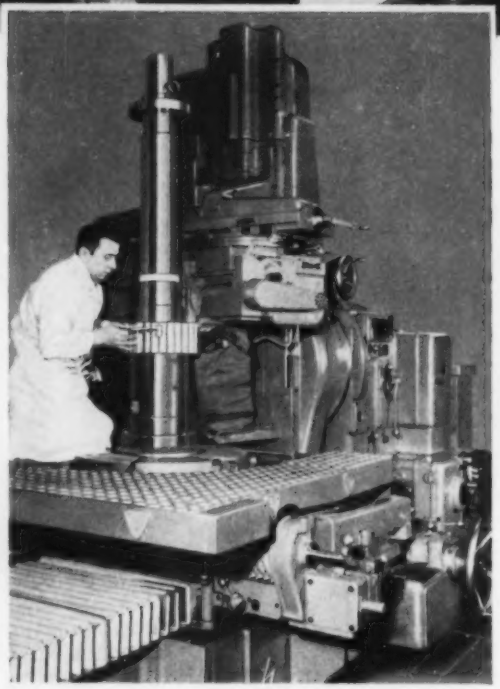
Where precision gears are required for defense or industry—Philadelphia has the equipment and manpower to do the job efficiently and economically.

The 141″ internal spur gears recently furnished for traversing the large Radar Screens on this fortress-like tower shown above were manufactured to the most critical accuracy requirements. The equipment will become part of Continental Aircraft Control and Warning System which searches out and identifies cruise-type missiles and aircraft through an intricate network of Air Force Radar Installations.

These five story towers, housing a complex electronic system designed and manufactured by the Sperry Gyroscope Company, are an integral part of the SAGE Complex.

The drive mechanisms furnished by Philadelphia Gear incorporate perhaps the most accurate large internal gears ever manufactured. The 141″ gears, having 282 teeth, are accurate within 20 arc seconds (17/1,000,000 part of circle) and the hardened and ground tooth pinions also manufactured by Philadelphia are accurate within 10 arc seconds (8/1,000,000 part of circle).

Where reliability and accuracy are required in precision or industrial gearing—you can depend on Philadelphia Gear for the best.



phillie gear®

PHILADELPHIA GEAR CORPORATION
ERIE AVE. & G STREET, PHILADELPHIA 34, PENNA.
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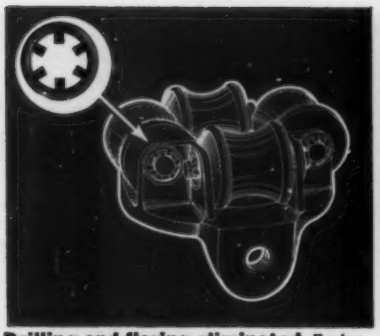
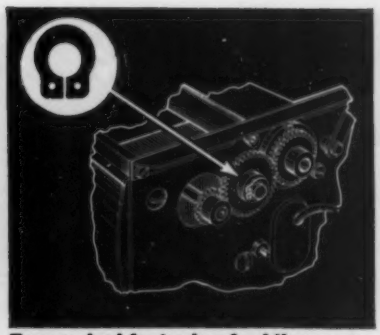
INDUSTRIAL GEARS & SPEED REDUCERS • LIMITORQUE VALVE CONTROLS • FLUID MIXERS • FLEXIBLE COUPLINGS
Virginia Gear & Machine Corp. • Lynchburg, Va.



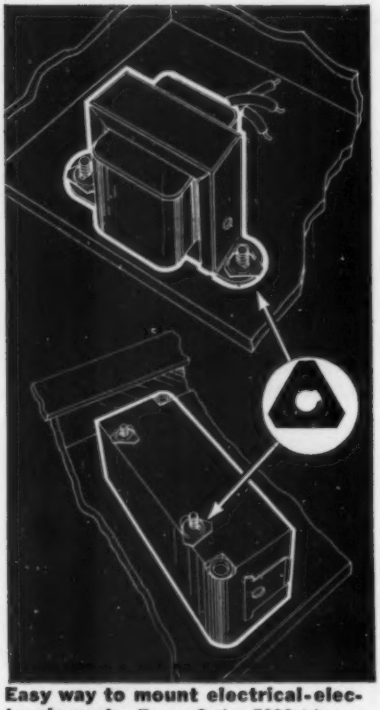
Drilling and flaring eliminated. Easier maintenance, a time saving of 50% and elimination of costly, time consuming drilling and flaring operations result when Truarc Series 5115 self-locking rings are used to retain rollers on pins in this electric cable guide. Extra long prongs enable ring to accommodate wide shaft tolerances.



Economical fastening for idler gear. Installing Truarc Series 5555 Grip Ring flush with hub insures precise seating of gear in this portable electrocardiograph assembly. What's more, the ring eliminates a nut and costly stud-threading operation of alternate design. **Typical savings amount to $365 per 1000 units.**

Cross-drilling and cotter pin eliminated. Here a Truarc Series 5305 self-locking triangular retainer replaces a cotter pin used to hold an electric-motor mounting bar. Both the cotter pin and the cross-drilling operation required in the original design are eliminated. **Typical total savings amount to $120 per 1000 units.**

Truarc self-locking retaining rings boost economy in wide variety of designs



Easy way to mount electrical-electronic parts. Truarc Series 5300 triangular nuts replace conventional nuts and lockwashers in mounting electrical parts like transformer (top) or Microswitch (bottom). Dished body of Series 5300 flattens under torque, eliminates need for lockwasher, simplifies handling and assures assembly.

...eliminate parts, machining, speed assembly

Easy application, elimination of more expensive conventional fasteners and reduction or elimination of machining operations are just a few of the savings resulting from the proper use of self-locking retaining rings. Rings replace threaded retainers and nuts, hairpin-type cotter pins, and a variety of cut, lock, and plain washers. They require no groove, or preparatory machining operations. Rings can be installed by unskilled labor, seated at any point on the shaft, automatically taking up any accumulated tolerances.

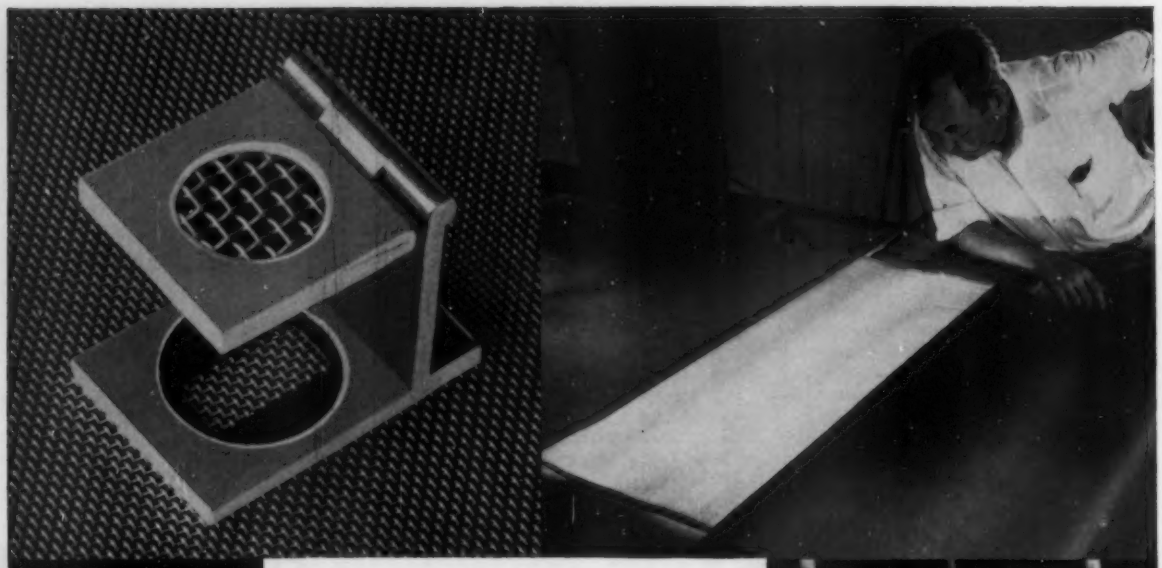
Four ring types are shown. One has a dished triangular body which locks the fastener on the shaft under spring tension, holds under moderate shaft tolerances and against extremely heavy thrust loads. Another, a re-usable Grip Ring, is ideal for ungrooved shafts, tubes, bosses, and studs. A third type is a triangular free-spinning nut with a dished body that flattens under torque, eliminating need for separate lock washers. The fourth, a push-on type, has an arched rim to provide high strength and extra long locking prongs which accommodate wide shaft tolerances.

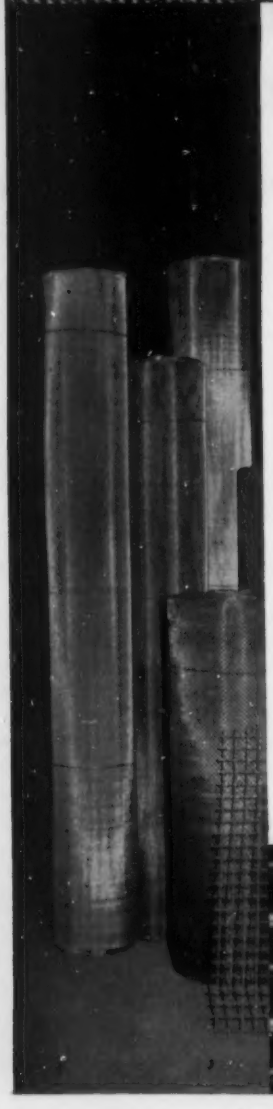
These are but four of the 50 functionally different types of Truarc retaining rings. They come in 740 standard sizes, 6 metal specifications, 13 different finishes. The entire Truarc line, including assembly tools, grooving tools, and 80 typical cost-saving applications, is covered in the new catalog RR 10-58. And remember, Waldes engineers are always ready to help you solve your application problems—whether they involve one of the standard Truarc rings or a "special" to fit your particular requirements. Waldes Kohinoor, Inc., 47-16 Austel Place, Long Island City 1, N.Y. p.15

WALDES
TRUARC®
RETAINING RINGS
Waldes Kohinoor, Inc., Long Island City 1, N. Y.

TRUARC RETAINING RINGS . . . THE ENGINEERED FASTENING METHOD FOR REDUCING MATERIAL, MACHINING AND ASSEMBLY COSTS

©1959 WALDES KOHINOOR, INC.





Who counts 'em?

CAMBRIDGE does . . .

. . . because *exact* mesh count and mesh size are the trademarks of Cambridge INDUSTRIAL WIRE CLOTH.

But, quality isn't the whole story. When you call Cambridge for industrial wire cloth, you also get service . . . prompt answers to your inquiries . . . quicker deliveries . . . and an experienced Field Representative who follows up your order to make sure our product is giving you the best possible service. Let us quote on your wire cloth needs. We manufacture wire cloth from any metal or alloy—including titanium—in nine basic weaves. Very likely, we have what you require in our warehouse right now. For samples or more information, call your Cambridge Field Engineer...he's listed in the yellow pages under "Wire Cloth". Or, write for FREE 94-PAGE CATALOG.

The Cambridge Wire Cloth Co.

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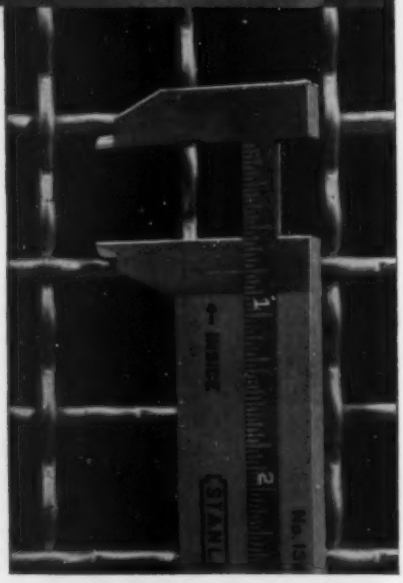
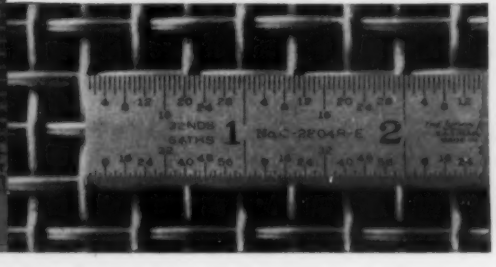
Manufacturers of Wire Cloth, Metal-Mesh Conveyor Belts, Wire Cloth Fabrications





When you buy Motor Starters--

YOU PAY FOR OVERLOAD PROTECTION

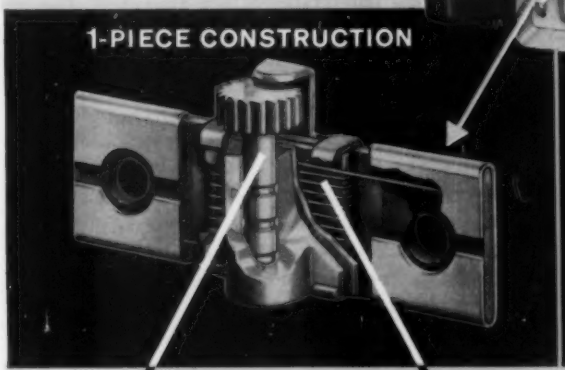
Only ONE-PIECE Overload Relays give 100% Protection • Only with ONE-PIECE construction can you *know* you've installed the heater correctly. Only with ONE-PIECE construction can you *know* the heater is exactly centered, or properly positioned, so that it performs according to its rating. Only with ONE-PIECE construction can you *know* your motors have full protection.

Only Square D has ONE-PIECE Construction • ONE-PIECE construction *eliminates* any possibility of heater misalignment. Square D melting alloy thermal overload relays can be installed only one way. They are tamper-proof. They are factory-assembled, are *individually* calibrated and tested. Repeated tripping will not affect accuracy.

Insist on Square D melting alloy thermal overload relays

Write for Bulletin 9M-275 for the complete story on Square D starters with ONE-PIECE thermal overload relays. Address Square D Company, 4041 N. Richards St., Milwaukee 12, Wisconsin.

...BE SURE YOU GET IT!



Heat-responsive element (solder pot) provides accurate response to overload, yet prevents nuisance tripping.

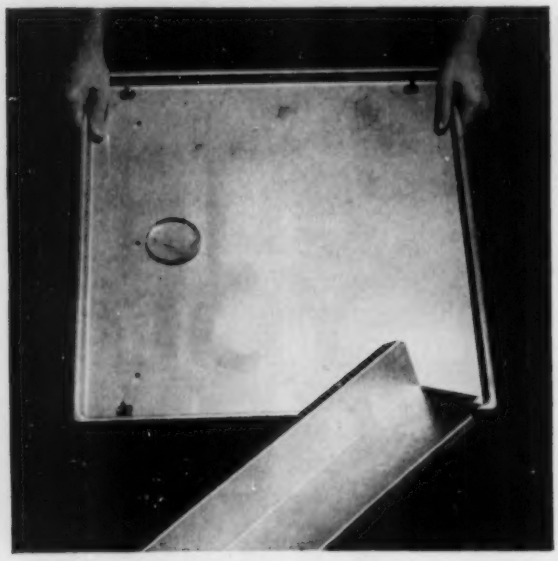
Heat-producing element is an integral part of overload unit. It's permanently joined to solder pot, can't become misaligned.

Individual factory inspection of every Square D melting alloy thermal overload relay means performance you can trust. Each unit is calibrated and thoroughly tested to make sure it will perform according to its rating.

EC&M HEAVY INDUSTRY ELECTRICAL EQUIPMENT...NOW A PART OF THE SQUARE D LINE

SQUARE D COMPANY

ARMCO STEELS FOR BETTER



Armco ALUMINIZED STEEL Type 1 Saves $2.50 Per Unit

By switching to ALUMINIZED STEEL Type 1 for various parts of their commercial frying units, a leading restaurant equipment manufacturer cut costs $2.50 on each unit. In addition, the durability of their equipment has been improved by using this hot-dip aluminum-coated steel in place of plated and painted parts.

Because it has resistance to a combination of heat and corrosion, high heat reflectivity and good fabricating properties, Armco ALUMINIZED STEEL Type 1 provides economical durability in applications such as auto mufflers, appliance parts, drying ovens, and heat exchangers.

Armco High Strength Steel Eliminates Wasteful Weight

Armco produces four grades of low alloy high strength steel that enable designers to achieve greater efficiency in the use of material and eliminate costly, burdensome weight. Each grade has high mechanical properties, but corrosion resistance and fabricating characteristics differ to provide steels that most effectively meet individual needs at least cost.

Produced in sheets, strip and plates, the durability and structural efficiency of these Armco Steels make them practical, low-cost materials for railway cars, pressure vessels, truck and tank trailers, and industrial and construction equipment subject to high stresses.

ARMCO STEEL CORPORATION, 3419 Curtis Street, Middletown, Ohio

Send me information on the following Armco Special Steels for these specific applications:_____

_____

Name_____

Company_____

Street_____

City_____ Zone____ State____

Besides the four steels described, Armco produces a wide range of other special steels that offer you additional opportunities to improve the performance and cut the cost of your products.

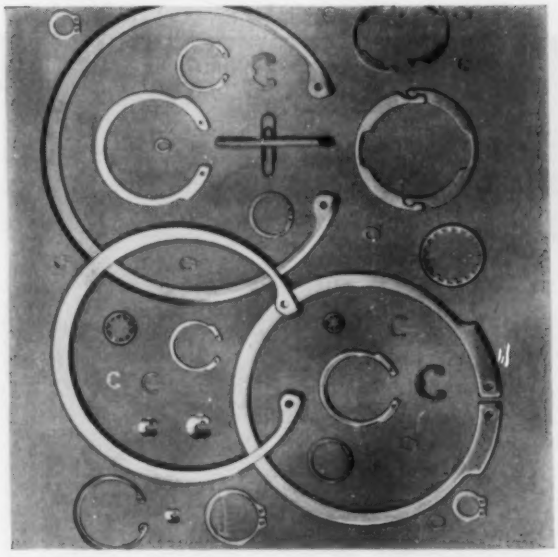
These Armco Steels include:

Armco ALUMINIZED STEEL Type 2	Armco Stainless Steels
Armco ZINCGRIP Steel	Armco Electrical Steels
Armco ZINCGRIP PAINTGRIP Steel	Armco Welded Steel Tubing

For complete information, just fill out and mail the coupon.

New steels are born at Armco

PRODUCTS...LOWER COSTS



Armco PH 15-7 Mo Stainless Steel Makes a Good Product Better

A leading manufacturer of retaining rings greatly improved the performance of his product and expanded its market by producing a complete line of rings in Armco PH 15-7 Mo Stainless Steel. The ultra-high strength, excellent spring properties, good corrosion resistance, and high temperature characteristics of this special Armco Stainless Steel make possible performance standards heretofore unobtainable at reasonable cost.

This is typical of the results obtained with Armco's Precipitation-Hardening Stainless Steels in diverse uses such as aircraft and missile components; chemical, food, and beverage equipment; and parts of nuclear reactors.

Armco Enameling Iron Cuts Costly Rejects

Made especially for porcelain enameling, this special Armco Steel enables designers to use all the advantages of colorful porcelain enamel and hold production costs to a minimum. The uniformly high quality of Armco Enameling Iron insures against impurities that cause enameling defects. The resistance of Armco Enameling Iron to sagging at firing temperatures keeps critical dimensions within tolerance, simplifies assembly, and improves appearance. Manufacturers of appliances, metal curtain walls, signs, and a wide variety of industrial products, find this special Armco Steel not only cuts manufacturing costs but gives them sales advantages as well.

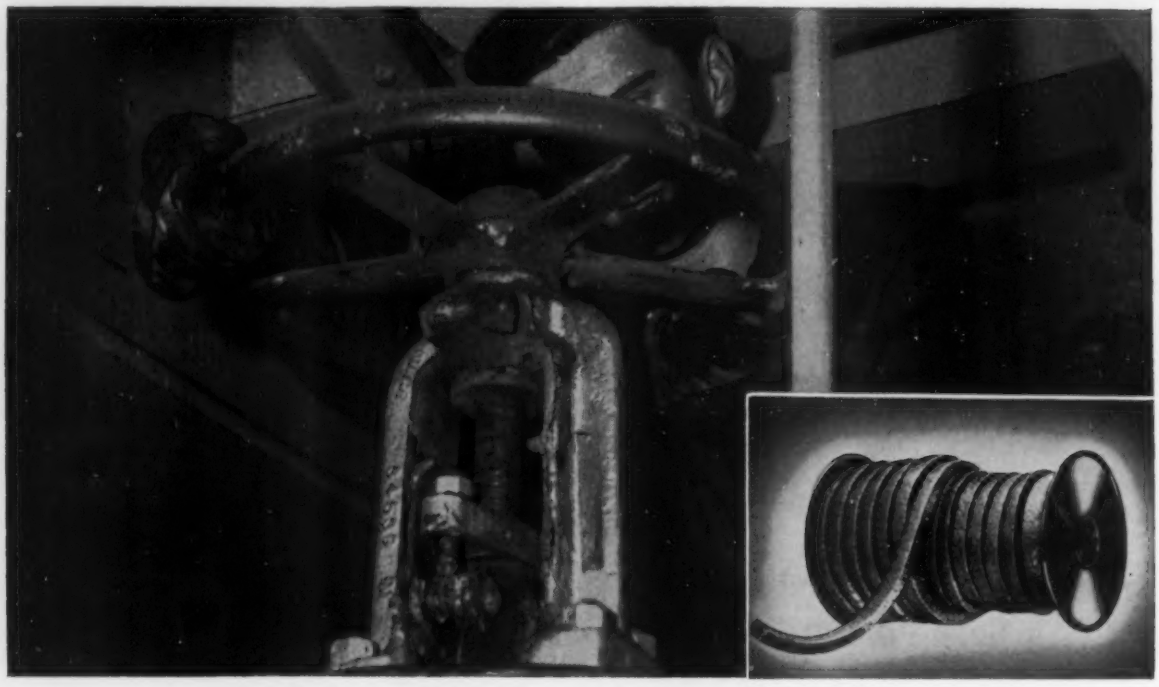
ARMCO STEEL

Armco Division • Sheffield Division • The National Supply Company • Armco Drainage & Metal Products, Inc. • The Armco International Corporation • Union Wire Rope Corporation

CUT COSTS, IMPROVE DESIGN AND PERFORMANCE WITH R/M PRODUCTS

PACKINGS

Complete information on the packings shown and many others is given in free booklet. Send for it today.
Packing Division, Raybestos-Manhattan, Inc.
Passaic, N.J.



Recommended for hot oil and high pressure steam: R/M High Temperature Valve Stem Packings

R/M High Temperature Valve Stem Packings—reliable solution to your hot problems

Today's boilers produce more heat and more pressure. They also produce more packing problems. To get reliable performance at temperatures as high as 1000°F or higher, specify R/M High Temperature Valve Stem Packings.

R/M's experienced engineers designed these packings to meet your toughest present and future needs. They eliminated practically all of the organic materials which break down under heat. The result is a packing which provides outstanding heat resistance and low volume loss. Solid lubricants are ground in during manufacture—you will find thorough compounding no matter where you cut into the packing. R/M uses braided asbestos—reinforced with Monel or Inconel wire to give you maximum extrusion resistance.

R/M High Temperature Valve Stem Packings are available in several types, for use with steam, hot oil, or hot gases. One of these types is ideal for your requirements. Call on the R/M engineers for their specific recommendations.

The complete R/M line includes packings and gasket sheets for use with gases, water, steam, oil, chemicals, solvents and food products. Feel free to call on R/M's experienced engineers for help in your packing problems.

R/M

Brake Blocks, Linings and Clutch Facings

Mechanical Packings and Gaskets

Abrasive and Diamond Wheels

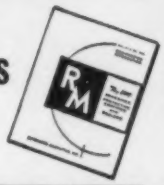
Industrial Drive Belts

Industrial and Automotive Hose

Conveyor Belts

SPECIALISTS IN ASBESTOS, RUBBER, SINTERED METAL, ENGINEERED PLASTICS

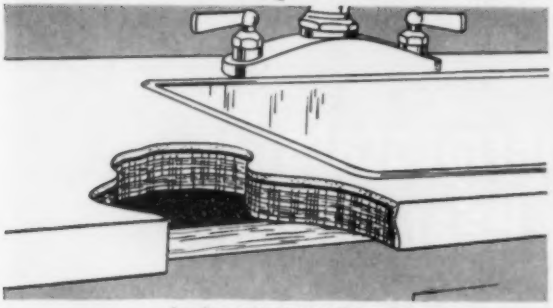
ADHESIVES



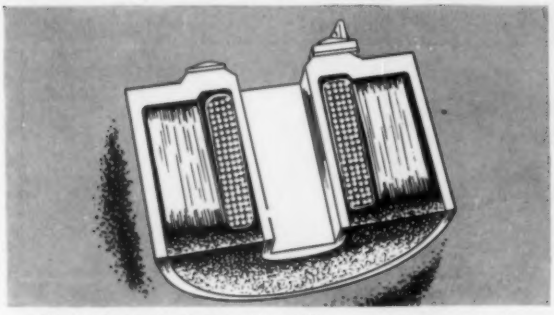
Send today for free copy of R/M Bulletin No. 700 on Ray-BOND adhesives, protective coatings and sealers.
Adhesives Department
Raybestos-Manhattan, Inc.
Bridgeport, Conn.

RUBBER

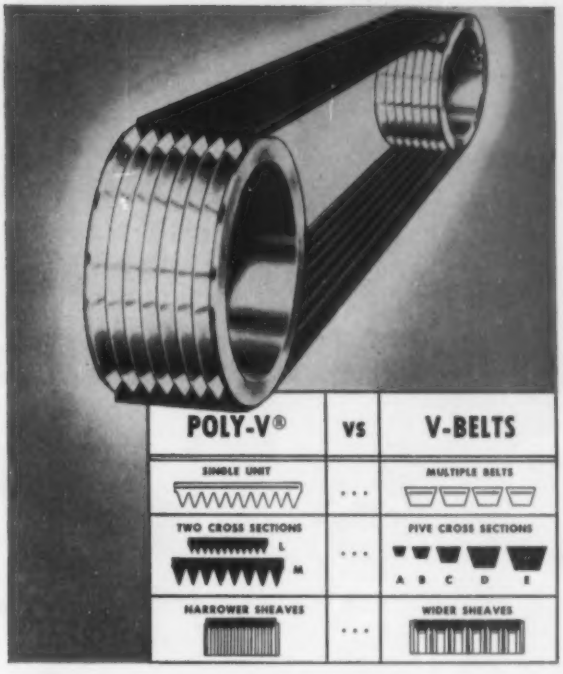
Write today for free booklet shown: full details on a wide variety of industrial rubber products.
Manhattan Rubber Division
Raybestos-Manhattan, Inc.
Passaic, N.J.



Bonding cabinet top to base



Sealing hundreds of wires with an R/M encapsulating compound



R/M Ray-BOND® Adhesives for faster production—lower costs

Ray-BOND Adhesives, tailored to the performance needs and the fabrication techniques of the individual manufacturer, are meeting widely varied requirements in products as diverse as aircraft engines and submarine cables, band saws, textiles and other porous materials. Adhesive bonding can cut your assembly costs, speed production, and simplify fabrication problems. It eliminates rivets and other fasteners, provides better heat conductivity, increases the life of friction members, and permits more effective bonding of dissimilar materials.

R/M offers you the benefit of its more than 20 years of experience with bonded assemblies for varied applications. Feel free to call on our engineers for help.

Put more power in less space with R/M Poly-V® Drive

Unique design of its single, parallel V-ribbed belt gives R/M Poly-V Drive* *twice* the tractive surface of a conventional multiple V-belt drive. This means Poly-V delivers up to 50% more power in the same space as a V-drive or equal power in as little as ⅔ the space! R/M Poly-V permits a more compact, lighter weight drive with less shaft overhang. Just two belt cross sections meet *every* heavy duty drive design requirement.

For light duty, single groove drive applications specify R/M FHP V-belts. Patented micro-positioned strength member and density controller make these the smoothest running V-belts made. Run quieter, cooler—and with less vibration. They're ideal for all kinds of motorized appliances, pumps and power tools. Whatever the drive design problem, rely on R/M specialists for the solution.

*Poly-V is a registered Raybestos-Manhattan trademark.

RAYBESTOS-MANHATTAN, INC.

FACTORIES: Passaic, N.J. • Bridgeport, Conn. • Manheim, Pa. • Paramount, Calif. • No. Charleston, S.C.
Crawfordsville, Ind. • Neenah, Wis. • Peterborough, Ontario, Canada

Rubber Lined and Covered Equipment

Sintered Metal Friction Elements

Asbestos Textiles

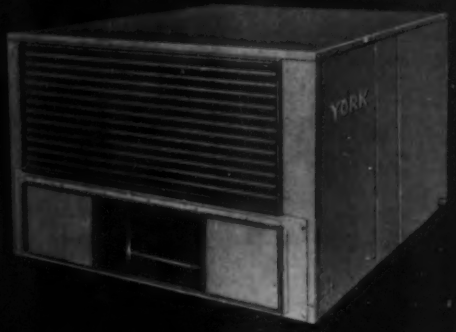
Industrial Adhesives

Teflon Tape, Packings, Sheets, Rods, Tubes

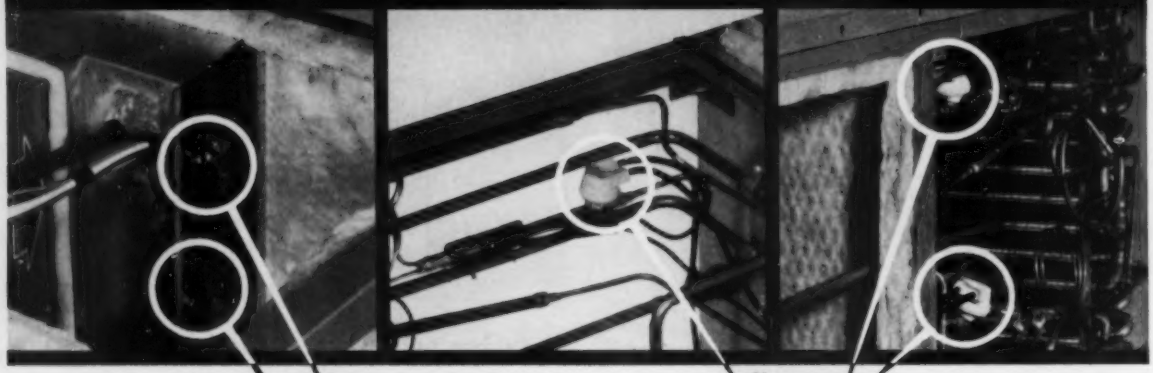
Engineered Molded Rubber and Plastics

CIRCLE 204 ON READER SERVICE CARD

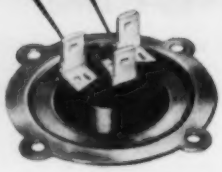
CIRCLE 21 ON READER SERVICE CARD



Five Klixon Thermostats team up on York Heat Pumps to assure efficient and safe operation



2 Klixon 20400L Thermostats are used to limit temperature of two supplementary heaters.



A Klixon 20220 Thermostat controls a small heater element of the flow-modulator.

2 Klixon 20221 Thermostats are mounted on the liquid line and shut down the unit on blocked blower.

Warmth indoors from zero degree outdoor temperatures or natural cooling in 115° ambients with one compact unit . . . that's what the York Heat Pump provides for homes or businesses.

In designing their versatile heat pump, York engineers specified *five* KLIXON Thermostats in each unit. The reason . . . they know from experience that rugged KLIXON Thermostats insure accurate temperature control and dependable, service-free operation.

York Corporation also uses KLIXON Thermostats on three types of attic-installed central heating-cooling units, both unit switch and reverse-cycle models.

York is another of the hundreds of leading manufacturers specifying and using KLIXON Controls. These controls are available in both sealed and open construction in a wide variety of types and sizes. Fixed temperature settings are custom calibrated at the factory to meet specific application requirements.

M&C field engineers will gladly help you make test applications of KLIXON Controls at your request. Send for new KLIXON Commercial Thermostat Catalog and get acquainted with the application possibilities on your products. No obligation, of course.

METALS & CONTROLS
3011 N. MAIN STREET, VERSAILLES, KY.
A DIVISION OF TEXAS INSTRUMENTS INCORPORATED
SPENCER PRODUCTS: Commercial Controls Department

ECONOMY, DURABILITY AND DEPENDABILITY are outstanding characteristics of these sintered metal gears. Parts like these are the result of close cooperation between Moraine Products and its customers from idea through design and development to production.

Moraine Products

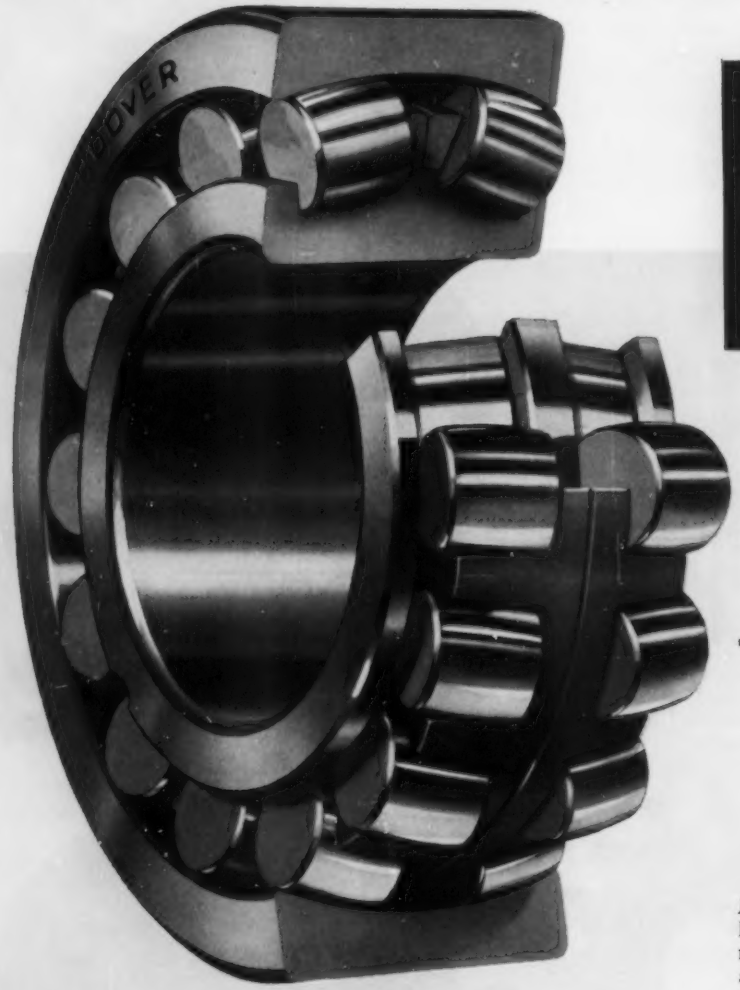
Vital parts for automotive progress • Division of General Motors, Dayton, Ohio

GM GENERAL MOTORS

CIRCLE 23 ON READER SERVICE CARD

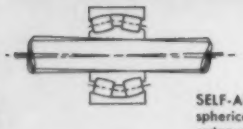
Now! *Hoover Quality*

HOOVER *super finish* RACEWAYS AND ROLLERS

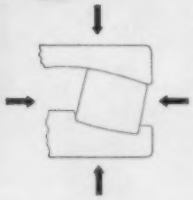


SPHERICAL Roller Bearings

Complete Range of Series and Sizes



SELF-ALIGNING—Hoover spherical roller bearings automatically compensate for shaft misalignment in any direction, either initially or dynamically under load.



RADIAL OR THRUST LOADS—Double row of large-size rollers provides capacity for heavy radial and shock loads. High contact angle provides substantial thrust loads in either direction.

ACCURATE ROLLER GUIDANCE is assured by heavy center flange guide, asymmetrical roller design and heavy machined bronze, land-riding retainers.

Hoover Quality spherical roller bearings have two rows of large-size convex rollers to provide exceptional radial and shock load capacity. In addition to the important features illustrated above, Hoover spherical roller bearings utilize a land-riding, machined solid bronze retainer capable of withstanding high stress. Hoover roller guidance features, plus precision matching of *Super Finish* rollers and raceways, assure uniform load distribution, low operating temperatures and enduring performance. Available in a complete range of series and sizes—with cylindrical or tapered bore.

HOOVER BALL AND BEARING COMPANY PE-11
5400 South State Road, Ann Arbor, Michigan

Please send information about the roller bearings checked:

☐ Have your representative call.

☐ Spherical roller bearings ... Bulletin No. 113

☐ Cylindrical roller bearings ... Bulletin No. 114

Name_____

Title_____

Company_____

Address_____

City_____ Zone_____ State_____

In Roller Bearings

ASSURE EXTRA LONG LIFE . . . SUPERIOR PERFORMANCE

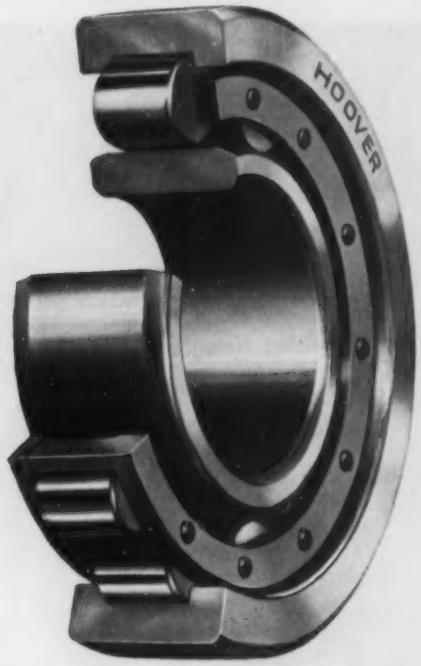
Depend on Hoover to set new high standards for roller bearing quality . . . *Hoover Quality!*

In roller bearings, *Hoover Quality* means that raceways and rollers are *Super Finished* to gleaming, mirror-like smoothness. It is this *Super Finish* that results in longer bearing life and superior performance.

Hoover enters the roller bearing field with complete lines of the most widely used of spherical and cylindrical types. Hoover roller bearings are accurately made of the finest of materials. They utilize the most successful of operating and design features. They assure you the best in roller bearing performance for a wide range of applications.

CYLINDRICAL Roller Bearings

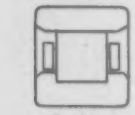
Complete Range of Series and Sizes

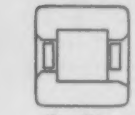


Hoover Quality cylindrical roller bearings are designed with crowned rollers that provide uniform load distribution for maximum radial load capacity and minimum friction. Because they are cool running, high speed operation under heavy radial loads is possible.

Rollers and raceways are *Super Finished* to mirror-like smoothness for quiet operation and long life. Retainers are machined solid bronze assuring strength and accurate roller guidance. Available in a complete range of series and sizes in the types pictured at right.

Type NU—Straight inner race


Type N—Straight outer race


Type NJ—Single flanged inner race

Type NF—Single flanged outer race

Type NH—Single flanged inner race with stabilizing ring

hoover

BALL AND BEARING COMPANY

5400 South State Road, Ann Arbor, Michigan

Zone Sales Offices and Warehouses

8581 South Chicago, Chicago 17, Illinois
290 Lodi Street, Hackensack, New Jersey
2020 South Figueroa, Los Angeles 7, California

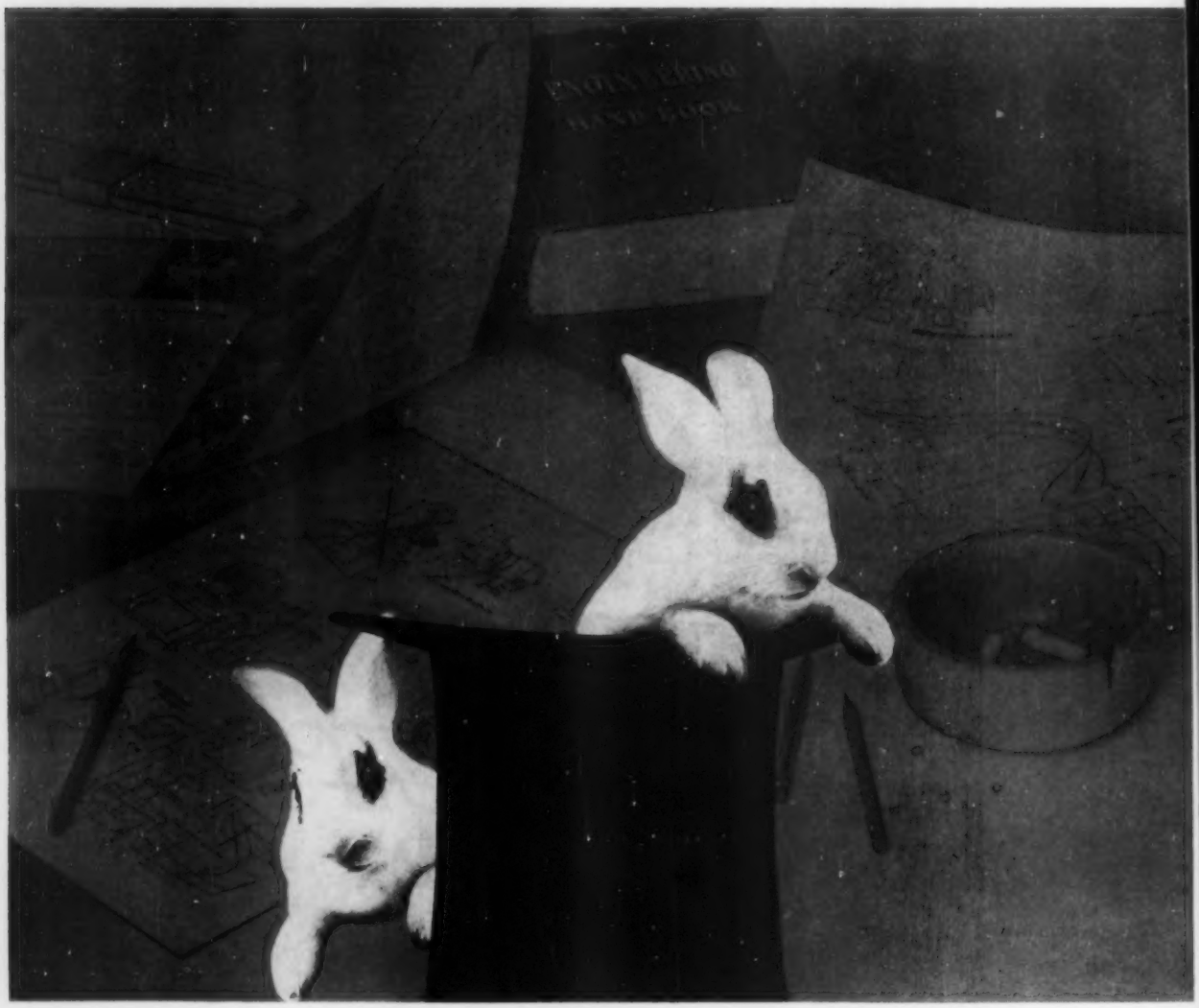
Bring out the FULL MAGIC of your own engineering know-how with Special REULAND Motors

Don't ever let a complicated drive requirement stymie your own ingenuity. If you have a design idea, go right ahead with it... leave the motor adaptation to Reuland.

Reuland cut its eye teeth in the motor business, many years ago, by supplying special motors for new design concepts. And, while our company now supplies many thousands of standard motors each year, we have never lost sight of the industry's continual need for something new.

Reuland's basic "Xpandable" design is ideally suited to special adaptation. For example, there are well over 2000 special designs in the Reuland Special Motor Library... one of which may very likely be close to something you may need right now.

Whether you are doing futuristic doodling... or designing for immediate production... cash in on your own creative designing talents. A single experimental motor, or a production run, will receive the same well known Reuland spirit of cooperation. Why not check into what we say.

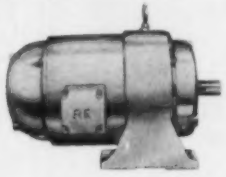


MULTI-DRIVE MOTOREDUCER

Shown here is a typical example of a Reuland multi-drive unit, as adapted for use on a screw conveyor bag filler machine. The primary motor turns the screw for high speed filling. For final, precision filling, a D. C. clutch cuts in the 128 r.pm. Motoreducer. Speed reduction ratios of as much as 100:1 are available.

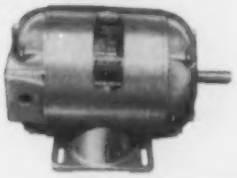
5-STAGE DRIVE CYCLE PACKAGE

A complete, five-stage operating cycle is handled by this one drive package... (1) 100 r.p.m. forward run, (2) immediate stop, (3) fluid-cushioned start again, (4) reverse direction and (5) return at 200 r.p.m. The complete cycle is accomplished by an internal fluid coupling...two-speed, reversing duty motor, gear reducer, and magnetic brake...*within one frame!*



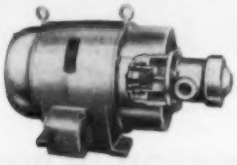
STALL DUTY TORQUE MOTORS

Reuland torque motors can be stalled or "locked" into a load with full current on. The units also automatically adjust their speed to intermittent load changes. Output torques can be changed, as desired, through the use of voltage varying devices. Available in ratings from ½ through 10 foot pounds...for maximum stalls of 5, 10, 20, 60 minute and *continuous.*



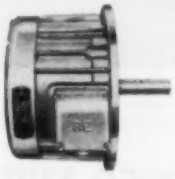
SPLINE COUPLED PUMP MOUNT MOTORS

Reuland spline-coupled hydraulic pump mount motors feature a direct connection between the pump and the motor's shaft... *inside the motor.* The installation is made by simply slipping the spline coupling onto the pump shaft...and attaching the pump to the endbell. The unit eliminates flexible couplings and platform mounts. Reduces mounting space almost 50%. Assures perfect alignment, automatically.



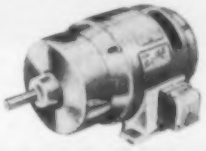
MACHINE TOOL MOTORS

These precision machine tool motors are a completely new type, especially made for the machine tool industry. They are compact in design and built to precise specifications like a fine tool. Their individual dynamic balancing...heavy duty ball bearings...low inertia, lightweight rotor...and even smooth-finished castings, make them a match for the most expensive machine tool.



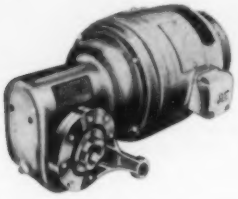
FLUID-SHAFT BRAKEMOTORS

Reuland Fluid-Shaft motors eliminate shocks and jerks and provide a smooth, gradual, stepless method of load acceleration. Power is transmitted through an internal fluid coupling and all starting inertias are absorbed in a cushion of oil. The Reuland "doughnut" magnetic brake... mounted on the output side of the coupling ...permits extending the motor shaft right through for load hook-up.



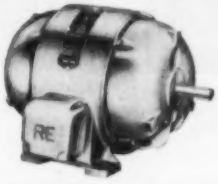
HOLLOWSHAFT WORM MOTOREDUCERS

This unique, right-angle Motoreducer features a *hollow shaft* that permits direct-coupling to equipment by merely inserting the drive shaft of the machine. No other mounting arrangement is required, except the torque arm which serves as an "anchor" for the Motoreducer. Eliminates the need for couplings, brackets, or belt and chain drives. Mounts in very tight areas.



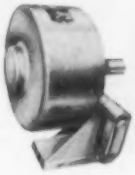
MULTI-SPEED MOTORS

Basic designs consist of three predetermined speed rating selections; 2-speeds, 3-speeds and 4-speeds. The motors are also available with three torque-horsepower-speed combinations. (1) Constant torque ...h.p. varies directly with r.p.m. (2) Variable Torque...h.p. variation is proportionate to the square of the speed, and (3) Constant horsepower...wherever h.p. need is constant regardless of operating speed.



DISC-TYPE MAGNETIC BRAKES

Reuland "through-shaft" magnetic brakes feature a fast and sure direct action principle. Levers and linkage are eliminated by a simple attraction and release action between the armature and "doughnut" type magnet. Available for use with all makes of motors in (1) *endbell* type, (2) *foot mounted* and (3) *foot mounted–complete with own bearings and shaft.*



MODERN POWER FOR MODERN-DAY PRODUCTS

...all in lightweight aluminum frames!

REULAND MOTORS

Our new general catalog will come in handy. Sent free on request. Describes the exclusive Reuland "Xpandable" design idea...Tells how you can benefit by using our free Special Motor Library.

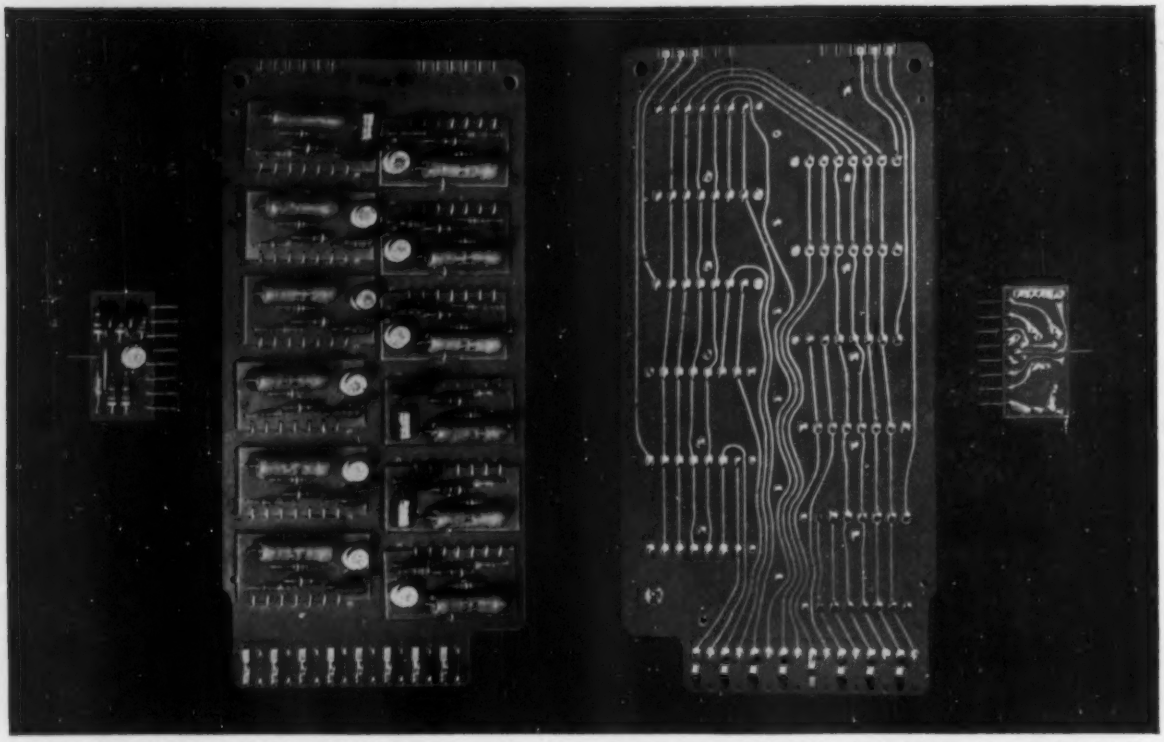
REULAND ELECTRIC COMPANY

WESTERN DIVISION: *Alhambra, California*

EASTERN DIVISION: *Howell, Michigan*

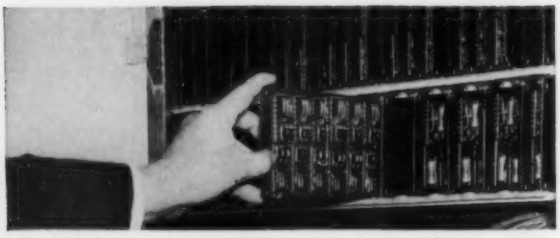
Distributors in all principal cities

SEE SWEET'S PRODUCT DESIGN FILE, SECTION 5A



In the electronic logic elements of the RCA "501" data processing system, transistors and other small components are mounted on plastic wafers with printed-circuit wiring (small units right and left, above). The wafers, in turn, are mounted on thin plastic boards, also with printed circuits (center, above). This modular construction reduces size of the system by 75%, increases reliability, reduces maintenance.

PRINTED CIRCUITS OF COPPER AND ALL-TRANSISTOR DESIGN HELP MAKE 75% SIZE REDUCTION IN RCA DATA PROCESSOR



Modularized circuit elements are installed in the system by sliding them in place. Contacts on outside edge make possible quick checkout and testing without removing boards. Many thousands are used in each system.

The "501" is designed to handle paper work—bills, reports, payrolls, etc.—accurately, economically, and at extremely high speed. It serves businesses ranging from banks and utilities to steel mills.

With the growing importance of miniaturization and reliability in electronics and nucleonics, Anaconda electrical copper products take new and varied forms—find new and more sophisticated uses.

In the compact new all-transistor data processing system shown above, the printed circuits are etched from Anaconda "Electro-Sheet" copper foil. This is electrodeposited paper-thin copper with quality carefully controlled to meet NEMA specifications. Bright on one side, it has a matte finish on the other for a firm bond to the circuit board. "Electro-Sheet" is furnished in various thicknesses to exceptionally close tolerances.

In other fields, the growing need for compact electrical assemblies which can handle high current densities calls for hollow copper conductors for fluid cooling. And for new environmental conditions, more difficult application needs, there are new copper alloys.

METALLURGICAL ASSISTANCE. Whatever your problem in electrical conductors, Anaconda metallurgical specialists will gladly help you select the metal—and the form or shape—best suited to your needs. See your American Brass representative or write: The American Brass Company, Waterbury 20, Conn. In Canada: Anaconda American Brass Ltd., New Toronto, Ontario.

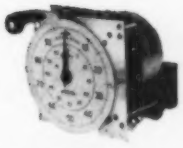
5946

ANACONDA®

ELECTRICAL COPPER PRODUCTS

Made by The American Brass Company

Miniature Might. Tiny Oyster Drills (*Urosalpinx Cinarea*) are noted destroyers of their much larger fellow-mollusks — oysters. One of 80,000 mollusk species, the Oyster Drill feeds on his victims through a shell-piercing snorkel.



Maximum Precision for the entire mechanism of this electric timer is assured by MPB bearings mounted on shaft ends and in gear trains. By reducing torque, these stainless steel bearings mean longer life and less maintenance for the timer.

Man with Miracles. Sales Manager Ken Broman heads MPB Sales Engineers in their engineering and consultative service to industry. One of these highly experienced MPB technical men is always ready to help solve your miniaturization problems.

More Miracles in Miniaturization

ACTUAL SIZE OF BEARINGS USED IN ELECTRIC TIMER SHOWN ABOVE

Designing and redesigning to meet modern requirements calls for miniaturization on a grand scale. Components for aircraft or outer space missiles must be reduced to minimum size and weight. Greater precision is needed in complicated, compact mechanisms and expert miniaturization is sought throughout industry. MPB helps you perform miracles in miniaturization by producing over 500 types and sizes of bearings ranging from 3/8" O.D. down to 1/10" O.D., with specials as required. For an illustrated catalog containing complete facts on these bearings, for engineering advice or both, write **Miniature Precision Bearings, Inc.,** 212 Precision Park, Keene, N. H.

MPB

Helps you perform miracles in miniaturization

HEAVY DUTY BALL BEARINGS . . . The ball bearings used in these motors are of the highest quality, with more than ample capacity to provide long trouble-free service under heavy loads.

BEARINGS CAN BE RELUBRICATED . . . Original factory lubrication will last for years in normal service—but convenient grease plugs are provided to permit relubrication that adds to motor life under severe conditions.

SECURELY SEALED FOR LOW MAINTENANCE . . . Both ends of these motors have running shaft seals to keep the bearings clean. Bearing housings are effectively sealed to prevent escape of grease.

Wagner Totally Enclosed Motors

Designed to give you Extra Protection

PROTECTED AGAINST CORROSIVE... ABRASIVE AND EXPLOSIVE ELEMENTS

WM50-7

Here are motors that will deliver full-rated horsepower under the toughest service conditions—that will help you keep your production rates up, and give you the kind of dependable, continuous operation that is so important to automation.

Type EP Motors are fully protected against damage from corrosion, dust, abrasives, fumes, steel chips or filings. Type JP is explosion proof as well—is designed and approved for use in explosive atmospheres.

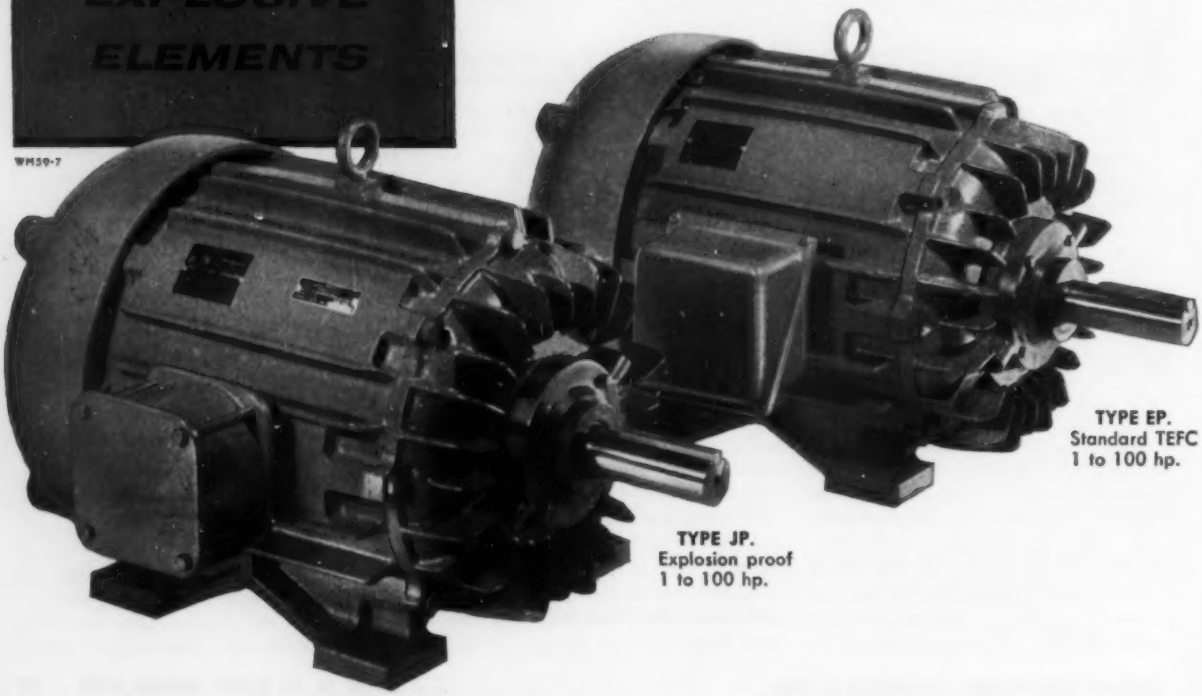
Integral ratings, 1 through 100 horsepower, are built in the latest NEMA frames, 182 through 445 US, with ribs that add mechanical strength and increase the surface cooling area.

Let your Wagner Sales Engineer show you how these protected motors can bring you savings on initial motor costs, maintenance costs, and in continuity of operation.

Branches and Distributors in All Principal Cities

Wagner Electric Corporation

6406 Plymouth Ave. • St. Louis 14, Missouri



TYPE EP.
Standard TEFC
1 to 100 hp.

TYPE JP.
Explosion proof
1 to 100 hp.

OTHER FRAME SIZES AVAILABLE IN RATINGS THROUGH 500 HP.

Technical data for gasket design and selection

How to get better sealing at no extra cost in fiber sheet gasket applications

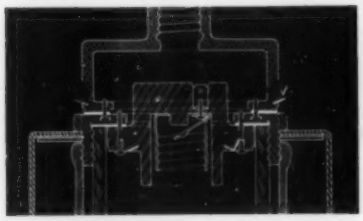
Economy is among the most important design objectives, whether it be an opportunity to reduce costs or a way to improve performance at no increase in price.

A new beater-saturated gasket material—Accopac N-852—is delivering such economy in a variety of applications where conventional plant fiber gaskets have been used.

In every case, N-852 was used at no increase in cost, and in many instances, this new material delivered a substantial bonus in better performance.

Accopac N-852 is made by a process pioneered and patented by Armstrong. In this process, cellulose fibers are combined with a synthetic latex binder and formed into dense, homogeneous sheets of unusual uniformity.

The binder in N-852 cannot be volatilized or extracted in any recommended application. As a result, gaskets cut from this new material will not shrink in use or in storage.



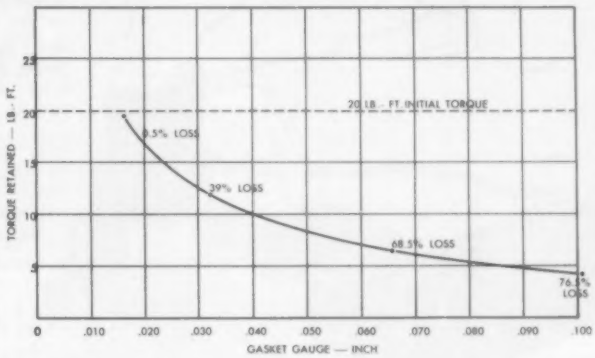
The efficiency of this vapor-tight light fixture was reduced when binder in a conventional plant fiber gasket volatilized and condensed inside globe. The non-extractable binder in N-852 helps eliminate problems of this type.

Accopac N-852 is recommended for any sealing job where glue-glycerine saturated materials are now being used. Typical applications are in caps for gasoline tanks and radiators, master cylinders for brakes, gear case covers, and hand hole covers.

N-852 is available in sheets, rolls, or die-cut parts. It can be obtained direct from Armstrong or locally through Armstrong Approved Gasket Fabricators throughout the country. Write to us for more information on Accopac N-852—or a list of Armstrong Approved Fabricators.

Factors to consider in determining gasket thickness

The thickness of a gasket material can affect its sealability, and this factor should be considered while a joint is in the design stage.



In this test, four gauges of one beater-saturated asbestos fiber gasket material were put in steel flanges and bolts torqued to 20 lb-ft. The flanges were heated at 300° F. for 18 hours, and retained torque was measured while flanges were hot.

A general (but not unqualified) rule is to use the thinnest gasket that will seal the joint. Aside from the obvious benefit of economy, research by Armstrong engineers discloses that thin-gauge gaskets also offer certain mechanical advantages.

One of these is better torque retention. A gasket's ability to retain bolt torque increases as its thickness decreases.

This is illustrated by the curve reproduced above. Note that a gasket .015" thick retains all but ½ of 1% of the initial bolt torque, while a gasket twice as thick retains only 60%. Torque retention decreases further as gasket thickness increases.

Less extrusion is another advantage obtained with thin gaskets. This is particularly true with straight rubber or the harder cork-and-rubber gasket materials.

There are, of course, factors that limit the use of thin gaskets. These stem from such things as non-parallel flanges, or flanges that bend or bow under bolt loads.

For example, if a gasket cannot be compressed more than the cumulative deviations from perfect parallelism of the two flange surfaces, a seal cannot be obtained. Similarly, if the design of the joint permits flange bowing between bolts, leaks will result. In both cases, one remedy is to increase the gasket thickness.

Gasket thickness is only one of many factors in gasket engineering that are under continuous study at the Armstrong Research and Development Center. Much detailed information on this work is contained in the Armstrong Gasket Design Manual. Write for your copy today.

For your copy of the Armstrong Gasket Design Manual, write to Armstrong Cork Company, Industrial Division, 7111 Irvin St., Lancaster, Pa.

Armstrong GASKET MATERIALS

. . . used wherever performance counts

←CIRCLE 30 ON READER SERVICE CARD

CIRCLE 31 ON READER SERVICE CARD

Easy to install! Easy to service! Hard to wear out!

LINK-BELT "RC" COUPLINGS

Here's a flexible coupling that's ✓simple ✓dependable ✓inexpensive

SIMPLE! Link-Belt "RC" couplings consist of two sprocket halves joined flexibly with a piece of roller chain. The chain is specially constructed for flexible coupling service—it is of single width construction, but has extra overall width and *divided rollers* which provide independent contact with each sprocket tooth . . . equalize load . . . compensate for shaft misalignment. Especially important, "RC" couplings are easy to install . . . easy to take apart and put together.

DEPENDABLE! Chain and sprocket halves are made of quality steel. In addition, sprocket teeth and chain parts are hardened. The resulting *extra* strength and wearability pays off in long, dependable service.

INEXPENSIVE! Extremely simple design holds down the cost of "RC" couplings.

HARDENED WEARING SURFACES of both chain and sprocket add extra wear-life to "RC" couplings.

CHOICE OF HOUSINGS

— for retention of lubricant and protection of the coupling. Style R — spun metal, vertical split. Style P — molded plastic, horizontal split.

FULL DETAILS are contained in Book 2363. For your copy, call your nearest Link-Belt office, listed under COUPLINGS in the yellow pages of your phone book.

LINK-BELT

"RC" FLEXIBLE COUPLINGS

LINK-BELT COMPANY: Executive Offices, Prudential Plaza, Chicago 1. To Serve Industry There Are Link-Belt Plants, Sales Offices and Stock Carrying Distributors in All Principal Cities. Export Office, New York 7; Australia, Marrickville (Sydney); Brazil, Sao Paulo; Canada, Scarboro (Toronto 13); South Africa, Springs. Representatives Throughout the World. 15.156-A

first in silicones

Dow Corning

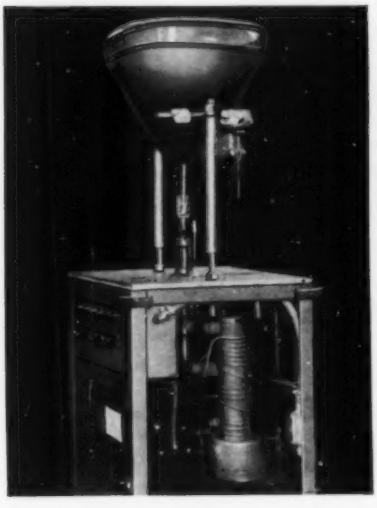
SILICONE NEWS

for design and development engineers • No. 68

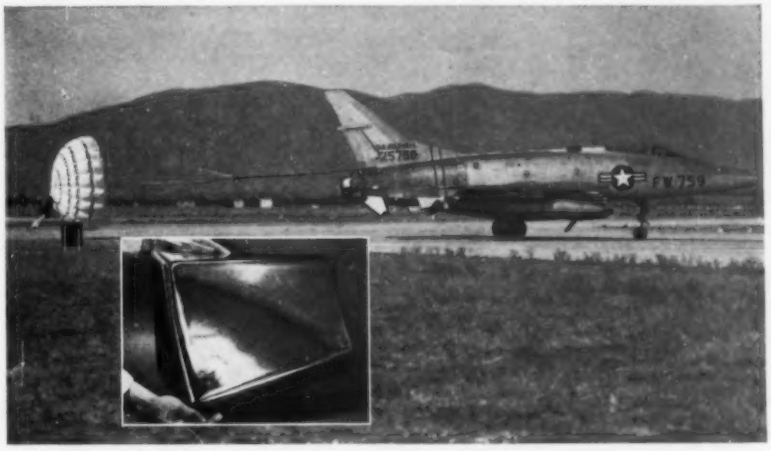
Provide Fine Vacua Quickly, Economically

Engineers in numerous industries credit several design improvements and manufacturing benefits to the use of silicone diffusion pump fluids. Examples include vacuum metallizing of plastics, electron microscopy, vacuum metallurgy and coating of glass, and production of television and cathode ray tubes.

Dow Corning silicone diffusion pump fluids offer a combination of properties that are put to practical advantages in attaining fine vacua. The property of primary importance is greater stability, but silicone fluids also offer such desirable characteristics as rapid recovery and quick pump down, inertness to air and metals, high vacuum, resistance to gamma radiation, and noteworthy economies.



The stability of silicone diffusion pump fluids makes it possible to release pump vacuum without first cooling the boiler. Exposure to air at operating temperature does not cause the fluids to decompose to gums or tars nor lose their vacuum pumping properties. For example, Dow Corning 704 Fluid, tested in a CVC type G-4 pump was unchanged in properties after more than 2,000 cycles of 12 minutes pump operation followed by 3 minutes exposure to the atmosphere at operating temperature. For more information about properties and applications, circle . . . *No. 242*



CONSTRUCT BETTER HEAT BARRIER WITH SILICONE-GLASS LAMINATES

Relatively unaffected by temperatures that destroy many structural materials, silicone-glass laminates helped solve a tricky insulating problem on the F-100 Super Sabre built by North American Aviation, Los Angeles, California.

The nylon drag chute of this jet fighter is stored near the afterburner — and in-flight temperatures of the storage area frequently climb to 450 F and higher. This is far in excess of the 200 F limit of the nylon chute, so North American had to provide some kind of protective case.

Originally made of one laminate of glass cloth and TAC (triallylcyanurate) with inner layer of polyester, with an outer coating of aluminum foil, the walls of the case simply wouldn't stand up in high temperature service. Various other combinations of materials were tried, and finally, a silicone-glass laminate coated with gold was employed as the outer layer.

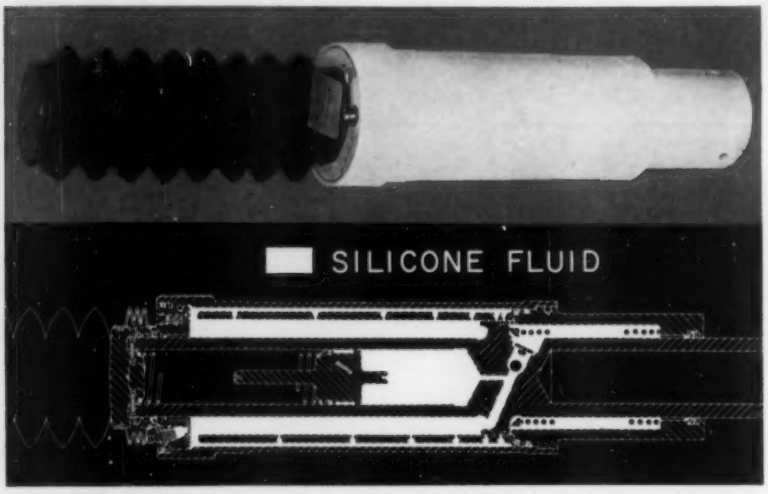
Able to withstand continuous exposure to 750 F and intermittent exposure to temperatures as high as 1200 F, the silicone-glass laminate proved more than a match for the temperatures encountered. It proved easier to work with than any other material, according to the fabricator, Barrier, Inc., Sun Valley, Calif.

Strong and lightweight, silicone-glass laminates retain a better strength-to-weight ratio at high temperatures than many light metals. Silicone-glass laminates are molded to a wide variety of shapes as structural and electrical insulating components for many different applications. *No. 241*

Trim Off Excess 'Fat'

Insulating electrical equipment with silicones not only reduces equipment size and weight, but it frequently also cuts the cost of the overall unit. Here's a typical example from Sorenson & Company, builder of scientific apparatus for industry.

Sorenson builds an a-c voltage regulator rated at 2 kva that's no larger than an overnite travel bag and weighs only 87 pounds. Comparable units on the market are half again as large and *(Cont. Pg. 2)*



DAMPING MADE EASIER

Engineers are no longer restricted by limitations imposed by organic damping fluids. Silicone fluids readily exceed most thermal requirements. This is nicely illustrated in the new Radar Antenna Buffers built by Houdaille Industries, Buffalo, New York.

Installed at the limits of antenna travel, these buffers are designed to prevent damage to the assembly caused by over-travel. The units dissipate the energy of extreme shock loads by hydraulic damping. Filled with heat-stable Dow Corning silicone fluid, the buffers absorb shock loads of up to 125,000 pounds in less than 9 inches of travel! The silicone fluid assures reliable operation down to —65 F, much lower temperatures than possible with the best organic fluids. And performance characteristics are not altered appreciably by temperature changes.

Engineers at Houdaille found that Dow Corning silicone fluid more than met all of their service requirements. Exceptionally resistant to cold, oxidation and breakdown under shear, the silicone fluid absorbs shock loads and minimizes the effect of temperature on performance to less than 1% per 100 Fahrenheit degrees. Another plus: noncorrosive, nonsludging silicone fluid assures minimum maintenance and exceptionally long service life.

Houdaille Buffers are being used on installations of the Air Force's Early Warning System for ICBM's. The buffers can also be engineered to cushion the impact of air-dropped equipment and for missile handling equipment. *No. 243*

INSULATION *(Continued)*

weigh up to 200 pounds. Why the difference?

The answer is the extra thermal stability obtained by using insulating materials made with Dow Corning Silicones. Sorenson engineers estimate they've lopped off 35% of the bulk and 55% of the weight by insulating the voltage regulator with silicones instead of Class A or B materials. The result is a much handier unit with a substantial increase in sales appeal.

But that's not all. By insulating the regulators with Dow Corning Silicones, Sorenson found they actually reduced the overall cost of the insulation and the assembled unit. In addition, the silicone insulation assures reliable power even when the voltage regulator is exposed to high ambients, moisture and corrosive atmospheres. *No. 244*

new literature and technical data on silicones

ESPECIALLY FOR TRANSISTORS—Dow Corning 5 Compound is a grease-like silicone dielectric used as a potting material for transistors. It has a wide range of serviceability (–100 F to over 400 F). Among its other outstanding advantages are purity, excellent dielectric properties, rapid heat conductivity, good heat stability, water repellency, and ease of application. A pamphlet contains the typical properties and information a designer wants to know. *No. 245*

KEEP 'EM COOL WITH SILICONE FLUIDS—Designers of electronic assemblies are using silicone fluids as dielectric coolants to solve problems created by extreme environmental conditions and miniaturization in control circuitry of aircraft, missiles, submarines, and industrial communication systems. A data sheet contains complete information for designers. . . . . *No. 246*

THE FULL STORY OF SILASTIC RTV

A new sound and color film tells the story of the Dow Corning fluid silicone rubber that vulcanizes at room temperature and requires no heat for curing. You can see how Silastic® RTV effectively resists weathering, moisture, oxidation, shock and vibration. The film aptly demonstrates how prototype molds and parts can be made quickly with this ready-to-use silicone rubber. Learn how you can arrange for a showing of this film in your own plant by writing for . . . . . *No. 247*

LONGER-LASTING PROTECTIVE COATINGS—An article reprinted from a recent issue of ***Products Finishing*** explains why the gloss retention and chalk resistance of silicone surface coatings are excellent . . . even when plant equipment is exposed to wide ranges of ambient temperatures over a period of years. By specifying silicone paints, enamels, and other surface finishes, you will decrease future maintenance costs, increase intervals between refinishings, and improve appearance. . . . . *No. 248*

Dow Corning Corporation, Dept. 8623, Midland, Michigan

Please send me: 241 242 243 244 245 246 247 248

NAME _____

TITLE _____

COMPANY _____

STREET _____

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DEVELOPMENTS TO WATCH...

New color-selector system for porcelain enamels . . .

. . . comprising 47 standard shades, has been developed by Porcelain Enamel Institute. The aim: to simplify color specification without in any way eliminating the possibility of using other, nonstandard shades. Color chips are now available for product use.

Information may be obtained from John Oliver, PEI, 1145 Nineteenth St, N.W., Washington 6, D. C.

Note: For more on colored enamels, see *PE* Aug 17, p 47.

Surface coatings that dry faster . . .

. . . offer built-in fungicidal properties, and show excellent toughness and durability, can now be made by incorporating tung oil as the vehicle, says US Dept of Agriculture.

A long-term research program in cooperation with the National Tung Oil Marketing Cooperative has paid off in a system that overcomes the previous limitations of this low-cost natural material (notably, a tendency to gel too quickly) and opens the way for new applications in metal primers, baking enamels and varnishes. Now, USDA is exploring combinations of epoxy resins and tung oil fatty acids and tung oil-safflower oil bases.

Samples of the new varnish vehicle, "in any reasonable quantity" for evaluation are available from E. L. Patton, Chief, Engineering and Development Laboratory, USDA Southern Regional R & D Div. New Orleans 19.

Titanium can be used at friction points . . .

. . . if paired with brass or bronze, and if loads are kept relatively light, I. S. Kaptyug and V. I. Syschikov report in the Soviet publication *Metalloved i Termich.* Acceptable performance can be obtained in such cases, despite the fact that titanium has a far lower friction resistance than either brass or bronze and under other conditions may wear 15 to 20 times as fast.

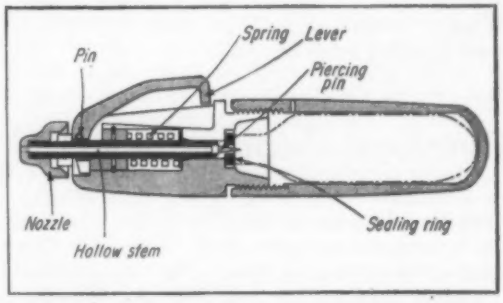
Alloying research has been less successful. The Russians report that tests of alloys containing Al, Cr, Fe, Mn, Pb & Si show little, if any, improvement in friction performance.

A needle valve that seats itself, acts as its own seal . . .

. . . on a metal-to-metal contact, and permits direct or remote control of high-pressure gases, just by finger-tip pressure, has been developed for Sparklets Ltd of London. Original aim was design of a new cartridge-operated cork-extractor for bottles. This is now going into production; but it is believed that the valve itself may have much wider application and it is to be produced as a separate unit.

The basic principle of the valve is simple: It works just by advancing a steel needle so it comes into contact with the head of a gas cartridge. (In the unit diagrammed, this is done by screwing the two halves of the unit together). The needle punctures the cylinder and is held in place by a spring. When the spring is released, by means of a control lever, the needle backs up just enough to allow the gas to flow out around it and be channeled to an operating nozzle.

The device can be made in almost any size; and, depending on the strength of the spring, almost any gas pressure can be handled.



Gas-operated valve features spring-loaded piercing pin that not only seats itself, but also acts as a seal until the spring is released by the lever.

While the valve is not yet ready for sale, distribution channels have been set up, and information is available from Quality British Corp, 120 Liberty St., New York 6.

DEVELOPMENTS TO WATCH...

Faster photographic films, with built-in "electrical shutters" . . .

. . . are promised by research now under way at Edgerton, Germeshausen and Grier, Inc, Boston, Mass.

Test exposures made in a sensitometer indicate that strong electric fields can increase both speed and sensitivity of photographic emulsions, and Jerome Rothstein of EG&G predicts that sensitizing substances can be found which will enhance electron avalanching and increase speed still more. It should be possible, too, he believes, to develop emulsions which become light-sensitive only when an electrical pulse is applied—creating an "electrical shutter."

For the tests, Kodalith stripping film was removed from its backing and mounted on a transparent electrode (tin oxide-coated glass). A second electrode was then placed over the film; and pulsed field applied by means of a dual thyratron circuit. The voltage across the electrodes was synchronized with the flash.

At high current intensities, says Rothstein, "a dramatic increase in both contrast and darkening" occurs; and there is strong indication that this stems from a real and significant increase in speed.

Thermal fatigue may not be as serious a design hazard . . .

. . . as has previously been supposed.

That's one important conclusion from an NASA study of jet engine bucket materials subjected to repeated 15 min stop-start cycles reaching 1700 F. Of the buckets tested, most showed evidence of thermal-stress fatigue cracking after about 10 cycles, yet there was only one case of complete failure in tests that ran up to 50 cycles. Even this sample ran for 31 cycles after the first cracks appeared and it fractured by mechanical fatigue, rather than by thermal fatigue.

The materials were nickel-chromium and nickel-chrome-cobalt alloys, vacuum-cast and wrought, some tested as-cast and others solution-treated and aged.

A Technical Note (D-125) has been prepared and is available from NASA, Washington, DC.

400-cycle ac solenoid for 600 F . . .

. . . is being developed by Aero Supply Mfg Co, Corry, Pa. This is a unit of the flat-faced plunger type, powered by a continuously wound high voltage coil. Its suitability for high temperature use, the company says, stems from the fact that it requires no rectifier. (Rectifiers generally can not stand temperatures in this range.) In addition, because it is an ac rather than a dc unit, output is relatively unaffected by temperature. Output force is, however, lower than that for dc solenoids.

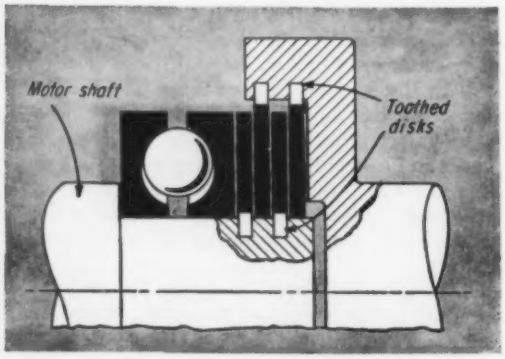
In the new design, the magnetic circuit includes a fixed core and movable plunger, slotted to reduce eddy current losses; and an outer case. The electrical circuit is simply insulated magnet wire wrapped on a ceramic spool. Terminals on prototype models are stainless pins; but the company plans to use stainless studs, glass-bonded to a metal ring, on production units.

The unit is still under test, and no production date has been set; but Aero Supply is welcoming inquiries.

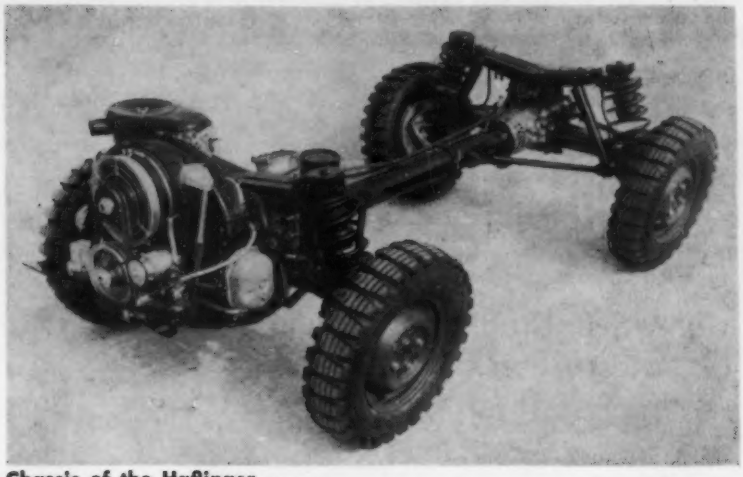
Centrifugal clutch for fractional hp motors . . .

. . . has steel balls, restrained by a split housing. Centrifugal force throws the balls outward, spreading the housing and engaging clutch. The motor thus starts under no load and picks up the load gradually.

Austrian manufacturer Josef Schischka, Hernalser Hauptstrasse III, Vienna 17, expects it to find applications on washing machines, centrifugal separators, and other appliances. —ARG



New clutch features centrifugal action of balls pressing against halves of split housing. As the diagram shows, the unit has toothed disks which transmit torque.



Chassis of the Haflinger . . .
Austria's mountain climbing jeep. Shown is rear-mounted engine and wheel suspension system. Tubular-steel housing for drive shaft to front axle is hinged to give speedy access to joints and linkage. This jeep will climb 65% inclines and can be driven along slopes up to 60%. Tip angle is around 45°.

Jeeps Get Star Billing at Frankfurt Auto Show

FRANKFURT, GERMANY—The recent automobile show here was noteworthy for an array of cross-country jeeps unveiled by German and Austrian manufacturers. Designed primarily for military requirements, the vehicles are also adaptable to jobs in forests and overland transportation.

Most revolutionary, of the three makes at the show, was the six-wheeled Flexomobil designed by Meili of Schaffhausen and built by Karl Kaessboher of Ulm. This jeep will operate on terrain normally inaccessible to tracked or crawler vehicles. Its stability on rough ground, so the designers say, derives from hydraulic linkages that can raise any one of the jeep's three axles off the ground, thereby throwing vehicle weight on the two remaining axles. Hydraulic control for the axles is located at the driver's seat.

The Flexomobil has central, front and rear axle assemblies. The three axles are designed so that front and rear assemblies can rotate around the central axle through an arc of almost 28 in. This arrangement adds considerably to vehicle maneuverability. Maneuverability is further enhanced by providing drive to all six wheels.

The normal Ackermann steering linkage, which actuates front wheels, is supplemented by a set of crawler style steering brakes. This combination, the designers say, gives the vehicle on-the-spot turning even though only a single differential assembly is employed in the transmission.

Power for the Flexomobil is a 100-hp (SAE rated) Ford V-8 engine coupled to a 10-speed transmission. Chassis flexibility precludes rigid drive shifts, hence roller chains transmit drive power from the central differential to front and rear axles. Front and rear wheels are independently sprung, but wheels at either end of the central trunnion are rigidly suspended.

To facilitate servicing and repair and keep stock of spares low, ballbearings of one size are used throughout the vehicle and wherever possible major components have been standardized. The 3-ton vehicle carries payload of 2½ tons and has top speed of about 50 mph. The American military reportedly was extremely interested in the vehicle.

Steyr-Daimler-Puch, Austria's leading auto manufacturer, displayed a 4-wheel drive lightweight cross-country vehicle—the Haflinger, named for a famous breed of horses reared in the Austrian mountains. Primarily for Alpine military operations, the vehicle is especially designed for fording and traversing or climbing steep slopes. It has a 4-wheel drive and differential locks to aid on rocky terrain, mud, sand, water, ditches and snow.

The horizontally-opposed engine has piston displacement of 643-cc and develops 25-hp (SAE). A high power axial fan in the air-cooling system is said to operate under climatic conditions ranging from arctic to tropic.

Front and rear wheels are independently sprung to give traction at all four wheels, and uniform distribution of driving power on rough terrain. Large wheel movement of 9-in., together with a springing and damping system that employs coil springs with internal rubber cushions and double-acting shock absorbers provide riding

Four seat jeep . . .
by DKW is covered on bottom by steel plates to protect transmission and other vulnerable parts. In design, the jeep patterns its US and British counterparts.

German jeep rides roughshod . . .
over terrain that bars ordinary tracked vehicles. The ease of maneuverability derives from an axle design that allows the vehicle to bend into a V. Further, a hydraulic system can lift any of the three axles off the ground to surmount obstacles. Flexomobil is intended primarily for carrying stores rather than personnel.

comfort that reportedly rivals the best passenger cars.

While operating this jeep, a driver can engage or disengage the 4-wheel drive and differential locks individually without interrupting flow of power from engine to wheels. Drive shafts are contained in tubular steel shells hinged to axle housing. A special joints on the front-wheel driving shafts allow optimum power transmission to front driving wheels even with toe-in.

Rough land over which the vehicle will operate calls for better-than-average braking system. The 8¼ in. aluminum-alloy drums are heavily finned to improve cooling and have cast-iron inserts to resist wear from brake shoes. Total brake-drum surface is 64 sq. in.; effective lining areas is 39 sq. in.

Work tests with the vehicle, whose top speed in fourth gear is 43 mph, indicate fuel economy of 36 mpg on the road. The Haflinger weighs 1290 lb and carries payload of 890 lb or four passengers.

Third company to display jeeps was DKW—Germany's 2-stroke engine experts. The DKW four to six seat models differed little in design and appearance from their US and British counterparts. Most noticeable difference was the staccato beat of the 3-cylinder, 2-stroke engine compared with the smoother purr of 4-stroke engines in US models.

Engine in the DKW jeeps is a 980-cc unit from the company's successful "1000" series of autos. Rating is 50 hp (SAE) to give maximum torque at 2100 rpm of 61½ ft lb. Drive to the four wheels is transmitted over a gear box assembly with eight forward speeds and two reverse. Top speed is slightly more than 60 mph with fuel economy 22 mpg. Unloaded weight is 2387 lb with maximum payload of 800 lb, including driver.

Military requirements have been met by providing a special cross-country carburetor and waterproof electrical equipment. Ground clearance is 9¼ in. Repairs and servicing have been facilitated by interchangeable front and rear axle assemblies, shock absorbers and springs. ■

Lightwave, Drafting and Metric Standards Get Most Attention at Conference

DETROIT—Display of a new lightwave standard of length, criticism of the lack of drafting standards and disagreement over adoption of the metric system highlighted proceedings at the 10th Annual National Conference of Standards.

Lightwave standard of length, to be proposed for universal adoption at the International Conference on Weights and Measures in 1960, is the wavelength of the orange light from krypton 86, (*PE Jul 27, p 14*). For standardization purposes, the krypton lamp is to be operated at the temperature of the triple point of nitrogen; standard so obtained is reproducible to an accuracy of one part in 100 million. It was exhibited during the National Conference.

Now under study at the National Bureau of Standards and other national laboratories, the new standard is expected to offer three important advantages: (1) freedom from variations of an artificial standard (plutonium meter) with time, (2) increased precision of measurement, and (3) availability of the standard of length in any laboratory.

On another subject—advisability of changing from the English to the metric system—there was wide disagreement. Opinions expressed during a panel discussion were primarily personal but to some extent reflected the attitudes of industries represented at the Conference.

Those opposing the switch represented the steel, machine tool and automobile industries. Those favoring the change were from industries based on mass and volume rather than on length as well as researchers in all fields and officials of communications industries.

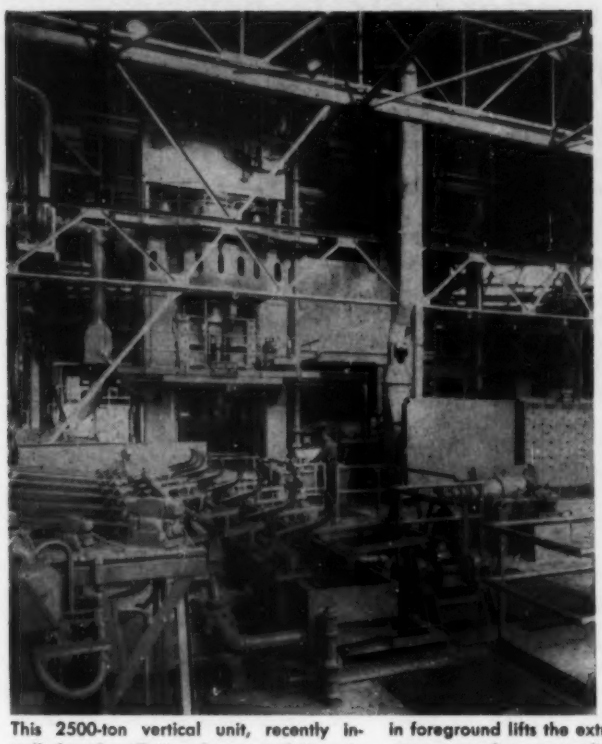
Conference was further enlivened by the charge that lack of uniform drafting practices is costing the US several hundred millions of dollars annually as a result of revised drawings, lengthy explanations, misunderstandings and mistakes. Frank H. Roby, executive vice president of Federal Pacific Electric Corp, voiced this charge which he cushioned by pointing out that the soon-to-be-published American Drafting Standards Manual, and the recently published American Standard Pallet Sizes Manual, will eliminate much of the current waste caused by nonuniform practices. ■

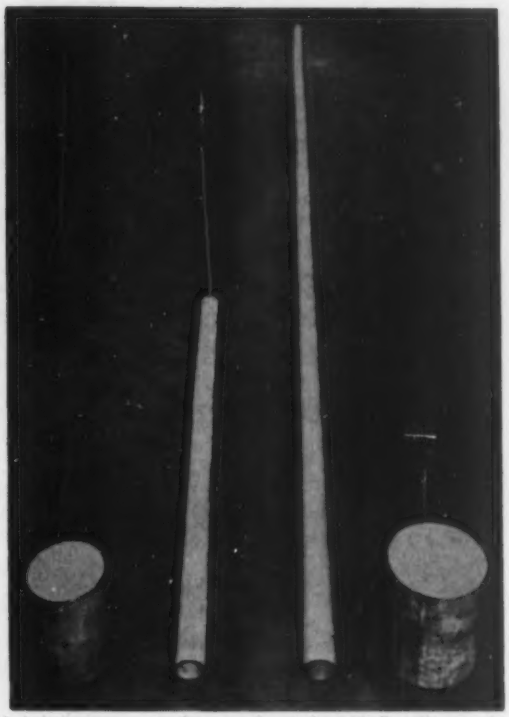
Current-path Verifier for Bomber's Complex Wiring

Portable current-path verifier, developed by Boeing Airplane Co, identifies individual wires in the complex wiring of a B-52G bomber in seconds. Amidst B-52G's 651 wire bundles, multiple-strand cables of wires have pinned connectors at each end. Each connector may have as many as 51 terminal pins. Continuity checkers and circuit testers are used early in the wiring procedure to check proper connection of a pin on one end of the cable to the correct pin on the other end. But in some phases of final assembly, and in modification and rework after terminal bases have been embedded in potting compound, and the wire bundles installed in the aircraft, continuity information is not enough. Checkers must verify that current is flowing through the proper wire. At this point, Boeing's "electronic witch," is applied. Weighing but 5 lb and powered by two small batteries, the sensing device is equipped with a hinged iron element that opens and closes like a pair of pliers, and is wound with a multi-turn coil. When the iron is closed around a "hot" wire, a voltage is induced into the coil. Through use of a miniature thyratron tube a small neon lamp is actuated to glow. Because the unit

is compact and free of power-supply cords, it can be used even in cramped quarters.

Giant Shell-extrusion Press Installed





This 2500-ton vertical unit, recently installed at Scovill Manufacturing Co's main plant in Waterbury, Conn, rises 40-ft above floor level and rests in a pit 45-ft below. Said to be the largest of its kind, the press nearly doubles capacity of previous models. The press and its control equipment are shown in background of photo, left (note man at console). Equipment in foreground lifts the extruded shells from pit, passes them to cooling tank and delivers them to storage. Hydraulic cylinders of the press are driven by two electronically-controlled, 500-hp motors. Electronic controls assure dimensional accuracy of shells. Contrasting size of shells from old and new presses is shown in photo, right. Billet for old press (left) is 7 in. dia, 11½ in. long and weighs 131 lb. The resulting shells are 11 ft-10 in. long and have 3 in. OD and 0.275 in. wall thickness. They weigh 98.7 lb. Billet for new press (right) is 9 in. dia, 12 in. long and weighs 234 lb. The resulting shells measure a total of 20 ft-2 in. long, have 3.250 in. OD and 0.265-in. wall thickness. The extruded shells each weigh 181-lb.

Engineers Air Views On College Studies

LAFAYETTE, IND.—How do engineers feel about their education after a bout with the practical working world? Purdue University put this question to 3800 of its alumni from graduating classes between 1911 and 1956. The alumni replied that they were happy with their choice of engineering as a career and with Purdue as an engineering school. But many found that their careers called for abilities not fully developed by schooling.

Asked what the goals of an engineering education should be, the respondents ranked sharpened reasoning ability highest. They said that "ability to think straight in the application of fundamental principles to new problems" is most important; "ability to organize thought logically" second; and "mastery of principles" third.

As for their own educational accomplishments, they say they are strongest in "mastery of scientific principles," next in "command of basic knowledge of branches of engineering (EE, ME, etc)" and third in "grasp and meaning of fundamental laws."

Humanistic-social goals, these engineers say, is relatively unimportant and the area where they boast least achievement. They rank an understanding of the influence of science and engineering on society and the influence of literature on civilization last.

On another question about the importance of certain technical subjects, an overwhelming majority (more than 75%) cited engineering sciences as essential or very important. These studies include properties of materials, electrical theory, thermodynamics, fluid mechanics and mechanics of solids. And the alumni think engineering drawing and graphics and engineering laboratories are equally important. About half think more than one year of physics is essential and about a third favor more than one year of chemistry. In mathematics, about 40% say study beyond calculus is needed and about 25% call for study beyond differential equations.

The importance of specialization, the survey finds, is more esteemed by the new graduate than by his more experienced counterpart. About half of all alumni say that "specialty engineering courses" are a must. But about only 40% of grads from 1911-15 vintage hold this view compared with 90% of the 1956 grads.

On nontechnical subjects, the en-

gineers rank speech and english composition very high. About 90% say these subjects are a "must" or "very important." Economics or business industrial management are considered important by about ¾ of the respondents. History, English literature, fine arts and philosophy found little support among Purdue alumni.

In this survey mechanical engineers constituted about ½ of those participating, electrical engineers about ¼ and civil and chemical engineers about 1/7. Nearly half of those answering graduated between 1946 and 1955. ■

New Gear Specs Ready for Spring 1960

CHICAGO—Unified system of gear specification is now being prepared by the American Gear Manufacturers Association (AGMA) to cover all spur, helical and herringbone gears. Superseding all previous gear classifications, the new system is expected to be adopted in the Spring of 1960.

In the new system all gears will be divided into 14 classes. Class 3, the lowest, will cover cast tooth gears, while class 16, the highest, will cover very precise gears. Classes 1 and 2, and classes above 16, may be added later as needed.

Classification is based on allowable tolerances in profile, run-out, pitch variation, and lead. Tooth-to-tooth composite tolerances for fine pitch gears, and total composite tolerances for coarse pitch gears are included.

Tentative classification includes: seven classes (3 through 9) to replace the present four commercial classes; five classes (10 through 14) to replace the present three precision classes; and classes 15 and 16, added as ultra-precision classes.

The classification system will be contained in a manual "that will assist in determining a satisfactory selection of gearing ranging from cast tooth gearing up through precision classes of gearing," according to a preliminary draft presented at the AGMA.

Included will be a wide range of pitches, from fine, 20 DP and finer, to coarse, 19.9 DP to ½ DP. Diameters will be up to 10 in. for fine pitch gears, up to 200 in. for coarse pitch.

—Felix Giordano

Heat Transfer Gets Transfusion from Frozen Blood Program

TONAWANDA, NY:—Research into the bulk freezing of whole blood is revolutionizing blood bank concepts and, simultaneously, sparking design of unusual refrigeration equipment requiring new techniques of controlling heat transfer. Ultracold (−320 F) liquid nitrogen appears to be the key to the problem, according to the Linde Co, in revealing recent research in blood and biological preservation.

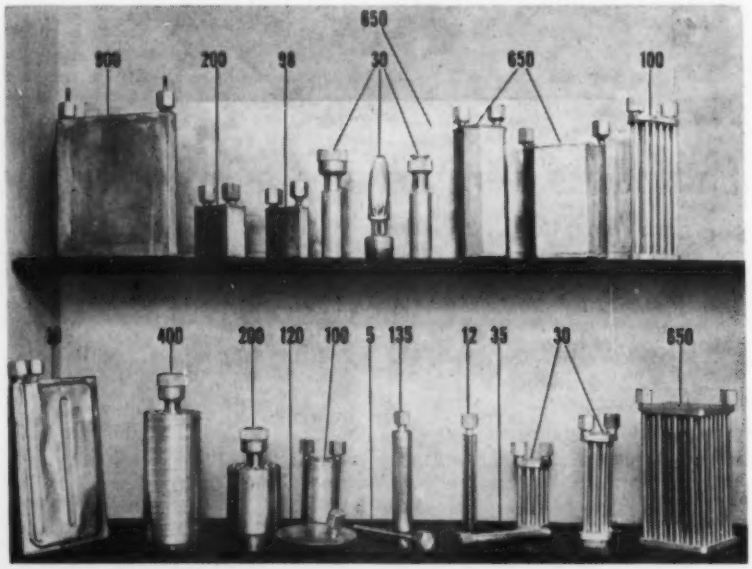
By plunging specially designed containers of whole blood into liquid nitrogen, freezing can be accomplished as fast as 1 pint in 45 sec. Blood thus frozen has been stored for over 2 years, with 85-95% of the cells recovered after thawing—and ready for use.

THREE DESIGN PROBLEMS

A workable storage system, now in the developmental stage, must face three engineering obstacles: sterile blood containers designed to speed freezing and thawing, storage refrigerators to maintain the containers at a temperature below −130 C indefinitely, and a ready supply of low-cost deep refrigeration.

Liquid nitrogen is readily available as a by-product of liquid oxygen production by separation of liquid air. As deep refrigeration prices go, liquid nitrogen is cheap (currently from 10 to 50¢/liter) and has been distributed by vacuum insulated trucks and tank-cars for several decades.

New vacuum insulations developed to cut distribution losses due to heat leak are being applied to storage refrigerators suitable for blood work. These super-insulations include dispersions of metal flakes in inorganic powders, and multiple reflective shields interleaved with thin glass paper. Now, nitrogen refrigerators can be built with evaporation losses below 3%/year. One container of this general type is used in the artificial insemination industry, and will main-



Experimental containers . . .
for whole blood frozen with liquid nitrogen are made of welded 6061-T4 aluminum alloy. Earliest containers (multi-tube at right) were designed to break blood volume into many smaller thicknesses (4-5 mm) more easily without damage to red cells. Numbers in photo show cc capacity. Detailed studies of liquid-solid heat transfer mechanism now allow up to 17 mm to be frozen in flat containers (top left). Container sterility is essential, thus careful welding is a must to prevent leaks from extreme thermal shock.

Storage refrigerator . . .
contains several blood containers in controlled-temperature bath of liquid nitrogen. Bubbling cold N_2 gas continuously through the storage space allows maintenance of a temperature from −100 C to −160 C to within ±1 C indefinitely. Refrigerator is double-walled vessel with high-performance vacuum insulation for low evaporation loss. A low-conductivity alloy steel tube connects inner and outer walls of the refrigerator. Blood containers are inserted into refrigerator through this tube.

tain −320 F for over 30 days on 25 liters of liquid nitrogen, Linde says.

The tough design problem has been the blood containers themselves (see photo left). To preserve live blood cells, the freezing method must drop the blood temperature instantaneously below the water recrystalization temperature so ice crystals cannot form or grow and kill the cells. The trick is to keep the exposed liquid mass small and yet have the container volume large enough for average transfusion purposes. By gently oscillating the container like a pendulum during both freezing and thawing, Linde researchers report that blood thicknesses up to 17 mils can be processed with high cell recovery and vitality. Also under development is a new technique (not revealed) of controlling boiling on the outer surface as the warm container is plunged into the liquid N_2. Studies like this have required ultrafast (up to 1000 C/sec) temperature measurements—accomplished with 5-mil Chromel P-Constantan thermocouples (for reproducibility) fused with carbon arcs, and standard amplifying and recording devices. ■

Gas Bearings Guide Satellites into Space

WASHINGTON—First American satellite was put into its orbit by a guidance system using air bearings, it was revealed by H. C. Rothe of the Army Ballistic Missile Agency, speaking here at the first International Symposium on Gas Lubricated Bearings.

Need for frictionless bearings in stabilization gyros in missiles became evident as far back as 1939. Two basic approaches were undertaken; a fluid bearing, and the suspension by means of pressurized gas. Because the Army felt it was not feasible to carry a development of both approaches to completeness, a decision was made in favor of the air bearing—mainly because this type gave easier manufacturing methods and better accuracy potentialities.

Results were so satisfactory that the Army is now using air bearings in accelerometers, pendulums and test equipment. The bearings are manufactured by private companies to Army specifications. But each new design is subjected to many tests before being released for production. Vibrators are employed to determine natural frequency and damping constants because shaft instability at critical speeds can still be a major problem.

Almost fantastic high speeds are also possible with the use of gas bearings. Development work is now underway by Analogue Controls Inc of Hicksville, NY, to build a small, high-speed grinder to operate between 400,000 and 500,000 rpm. This speed is much above the usual top speed of 100,000 rpm that can be obtained with more conventional oil-lubricated bearings. G. K. Fischer of Analogue, who presented a paper at the symposium on static and dynamic characteristics in co-authorship with J. L. Cherubim, also of Analogue, and O. Decker of the Stratos div of Fairchild Engine and Aircraft Corp, feels that there is no reason why gas bearings cannot handle speeds up to 1,000,000 rpm. In his talk, Fischer said that most factors that influence the stable operation of gas bearings at high speeds have been successfully isolated by his group. These are critical speeds, unbalance, film stiffness, whirl and air hammer. Isolation and identification of these factors have been due primarily to the instrumentation developed.

A critical evaluation of advantages of gas bearings was made by Prof Dudley Fuller of Columbia Univ and Franklin Institute. He noted that the bearings have already proved superior to conventional oil bearings in applications where they must operate at extremes of temperature.

The symposium which was managed by Franklin Institute and sponsored by the Office of Naval Research in cooperation with 9 government agencies attracted some 600 participants—including not only Western European nations but also Rumania, Austria, Israel and Japan. Some of the presented papers will be discussed in a more detailed analysis in the Nov 23 issue of PRODUCT ENGINEERING.

—Nick Chironis

Quick Test for Light Metals

Is it Al or Mg? Alloyed or pure? From Germany comes a reminder of a fast, simple test. All that's needed is a 10% or 20% caustic soda (sodium hydroxide) solution and a piece of cloth or an eyedropper.

Drop or wipe the solution on the metal; wait 10 min; then take a look:

Small gas bubbles indicate the metal is aluminum; pure, if the treated area is still bright after rinsing in water; alloyed with Cu, Zn, or Si if a black stain or coating appears. If the coating wipes off easily, the alloying elements are Cu and Zn; if it does not, a considerable amount of silicon is probably present.

No bubbles and no coating means it's definitely Mg. ■

Cylinder Manufacturers StandardizeDimensions

DETROIT—Cylinder manufacturers finally agree on universal method for dimensioning the mountings and overall envelopes of power cylinders. Locations for key dimensions were approved, and letter designations were given by Committee on Cylinder Designation of National Fluid Power Association (NFPA). The goal is to

incorporate the new method into future catalogs of all cylinder manufacturers so that the design engineer can directly compare sizes and mountings; the draftsman can easily copy the dimensions for layout.

It was agreed that the primary reference point for all dimensions will be some point on the piston rod. In a pin-ended rod, for example, the reference point will be at the center of the pin; a different reference point will be given to other rod-end designs. Each specific dimension will carry identifying letters that are consistent for the dimension; for example, the letter Y will always be distance from rod reference point to first port, and P is distance from rod-end port to blind-end port.

Also discussed during 3-day meeting were universal methods for rating valves, pumps and accumulators. Although no agreement was reached on these controversial topics—there are almost as many rating methods as manufacturers—considerable ground work was done. —Frank Yeaple

Swiss Foundation Aids Underdeveloped Nations

ZURICH—A Foundation for Technical Development Aid has been established here to promote technical development of underdeveloped nations. It will be financed by subscription from private Swiss firms.

In its early stages, the Foundation will concentrate on technical training for workers in beneficiary countries. Under the education program, Swiss instructors—either technicians or expert workmen—will conduct classes for trainees in their native lands. Three fields will be covered in these classes: (1) upkeep and operation of carburetor engines, (2) upkeep and operation of electric motors and electric engines and (3) training in carpentry, masonry and other crafts.

Trainees will be chosen to fill jobs in operating plants or industrial plant under construction. Some will alternate class work with on-the-job experience in industry. In special cases, unusually able students will continue their training in Swiss technical schools. These students will eventually become instructors, possibly replacing Swiss teachers.

The Foundation is headed by Dr Hans Schindler of this city. Other members of the working committee are Dr Fritz Real; Dr Gilbert Etienne, Counsellor for the Federation of Swiss Association of Watch Manufacturers; Dr Arthur Fürrer, vice-director, Nestlé Alimentana Co; Dr Peter Gloor, manager Swiss Transit and World-trading Firm; and Madame Annemarie Im Hof-Piguet, Bern. ■

COMING EVENTS

NOVEMBER

9-11 . . . . Institute of Radio Engineers; 4th IRE Instrumentation Conference and Exhibit, Atlanta Biltmore Hotel, Atlanta, Georgia.

9-11 . . . . Steel Founders' Society of America, 14th Technical & Operating Conference, Carter Hotel, Cleveland, Ohio.

12-14 . . . . American Society of Industrial Designers, Planning by Design Conference, Hotel Statler, New York.

16-20 . . . . American Rocket Society, 14th Annual Meeting, Washington, D. C.

17-20 . . . . Packaging Manufacturers Institute's Show, New York Coliseum, New York.

29-Dec. 4 . . . . American Society of Mechanical Engineers, Annual Meeting, Chalfonte Haddon Hall, Atlantic City, N. J.

30-Dec. 4 . . . . 27th Exposition of Chemical Industries, New York Coliseum, New York.

DECEMBER

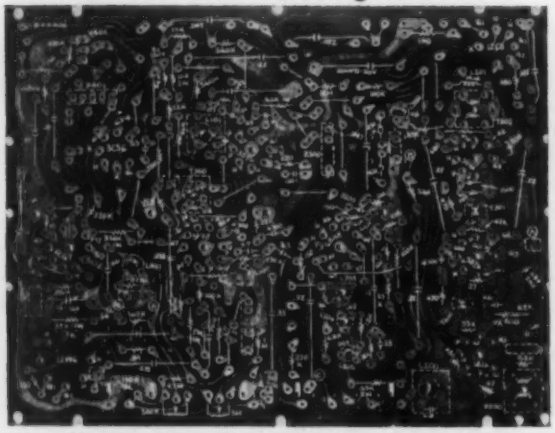
2-4 . . . . American Institute of Mining, Metallurgical and Petroleum Engineers, 17th Annual Electric Furnace Conference, Cleveland Hotel, Cleveland, Ohio.

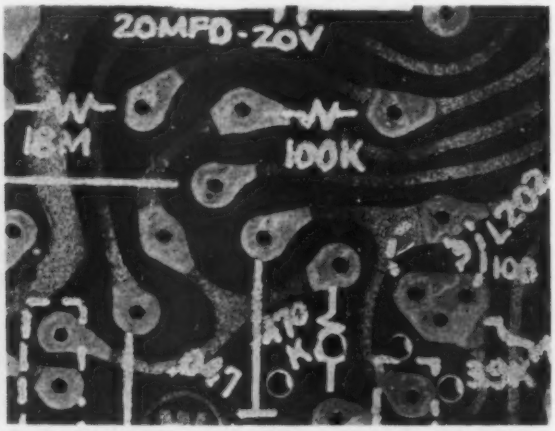
13-16 . . . . Materials Handling Institute, Annual Meeting, Savoy-Hilton Hotel, New York City

JANUARY

12-15 . . . . Society of Plastics Engineers, 16th Annual Technical Conference, Conrad Hilton Hotel, Chicago.

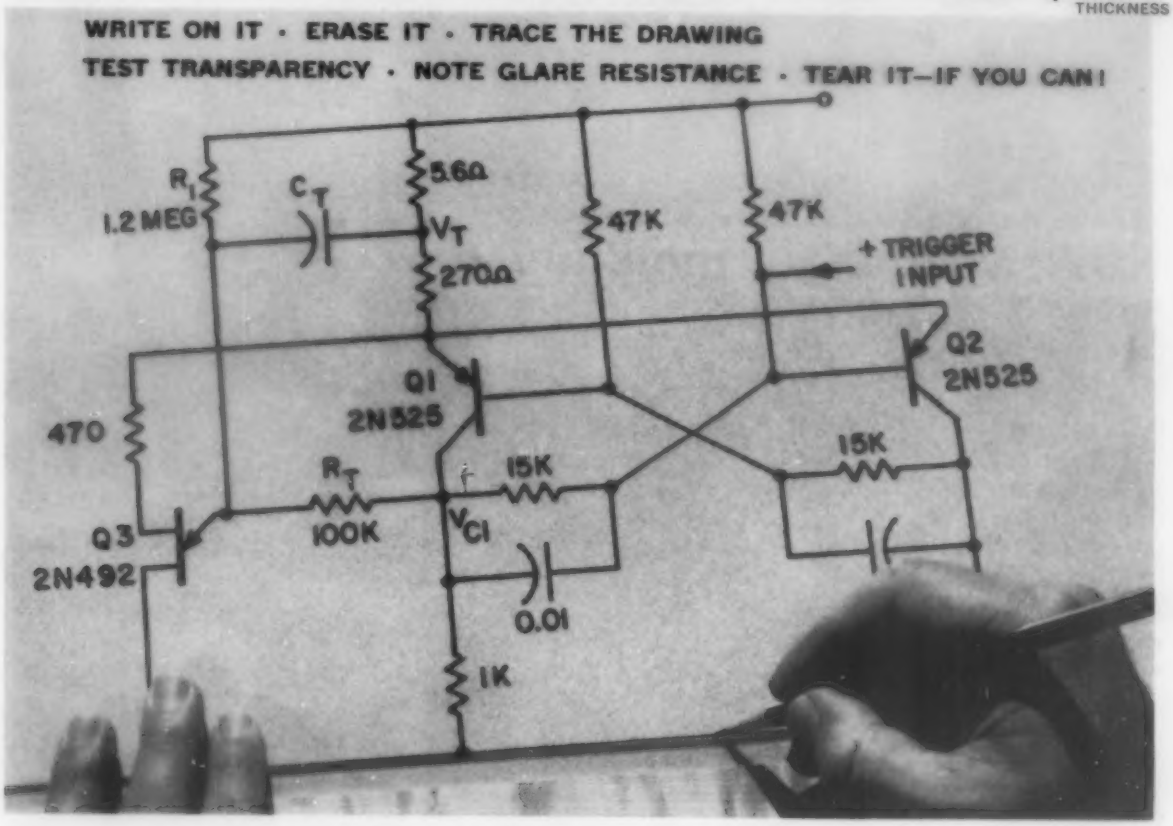
Takes Puzzle Out of Tracing Trouble





Printed circuit boards, manufactured by Westinghouse's Television-Radio Div, have identifying symbols and values to simplify maintenance and servicing. Packaged circuits are labeled by numbers; dashed outlines enclose the terminals included in these components. Circled letters (A, B, etc) are test points. Voltage supply lines are identified by symbol, B+, and voltage, 120 v. Where special sizes of resistors or capacitors are used, the size is labeled. Jumpers are solid lines on board. Entire circuitry is sealed against corrosion by a coating of green plastic material to avoid high resistance leaking sometimes caused by perspiration and skin oils in servicing. (For other examples of printed circuit board design, see cover and p 5.)

THIS IS CRONAFLEX® DRAFTING FILM (.004") THICKNESS



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CRONAFLEX* is the only drafting film made entirely by Du Pont. It is an exclusive combination of a superior surface on Du Pont's unique CRONAR* polyester film base. Du Pont makes the surface and the base in one complete process that assures you of consistent quality. Every piece of CRONAFLEX Drafting Film has been subjected to the most careful supervision during its entire manufacturing cycle. The .004" thickness of this new drafting film makes it easy to handle and to file.

The surface: ideal for pencil . . . erases easily . . . smear-resistant . . . clearer than cloth—you get faster print-through speed with greater uniformity . . . accepts ink.

The base: holds size . . . flexible . . . unexcelled strength . . . moisture-resistant . . . easy to handle . . . lies flat.

CRONAFLEX Drafting Film is available *now* in many put-ups and sizes . . . in either roll or sheet form . . . matted one or two sides. For additional information, and the name of your nearest dealer, *clip* the coupon on the preceding page (you'll never be able to tear it!) and send it in.

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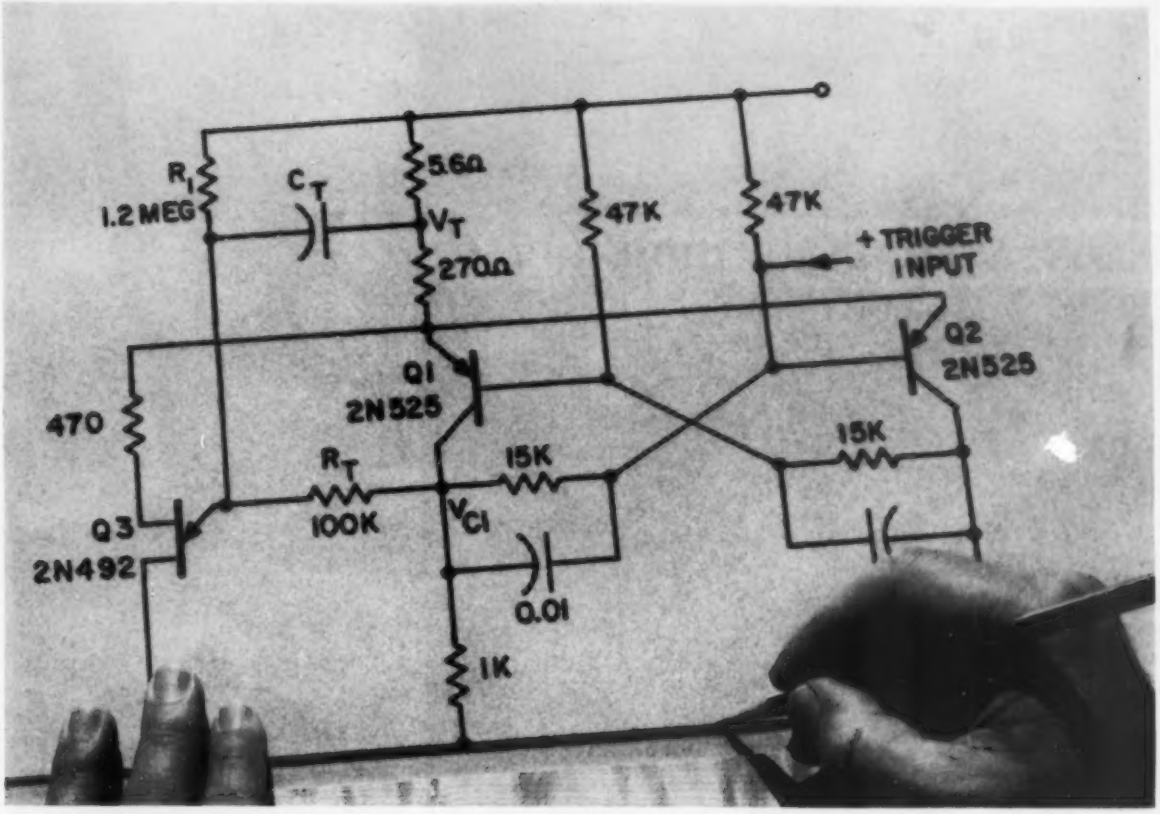

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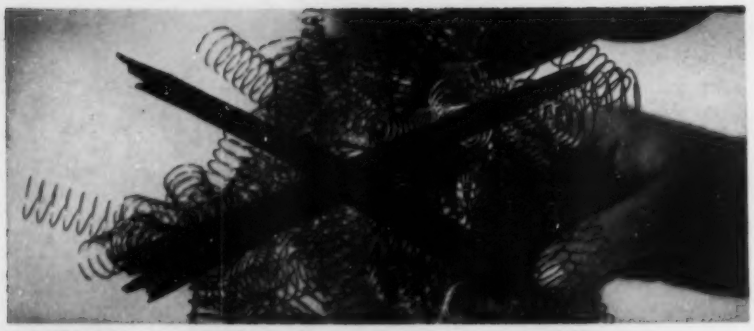

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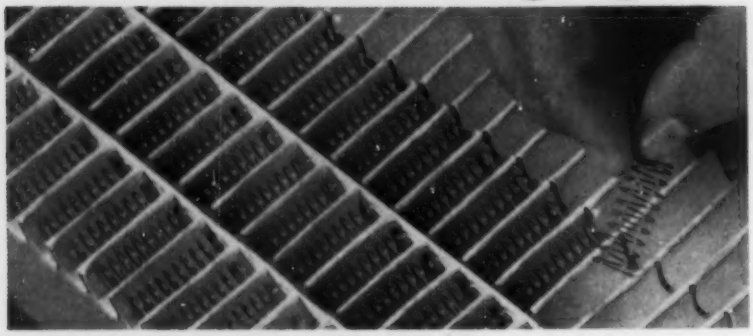

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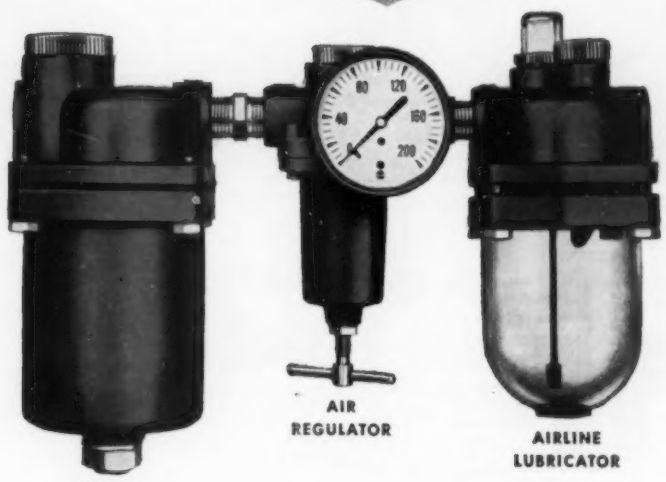

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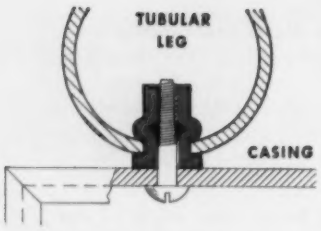
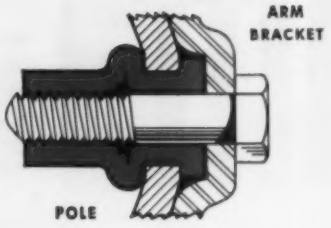
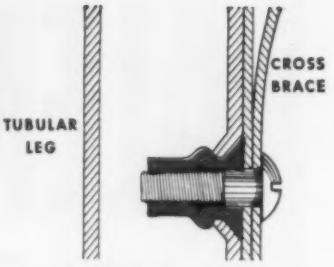
Only B.F.Goodrich Rivnuts® solve all these fastening problems so well



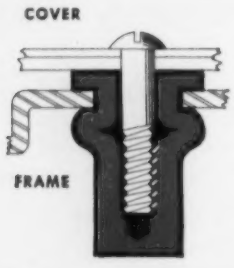
One man installs Rivnuts from one side in seconds—speeds assembly of *barbecues*. Permanent nutplates in legs save time in faster knockdown, too.



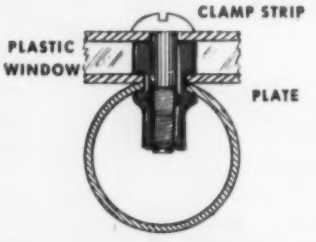
One man does the work of two, assembling arm brackets on *light poles*. Tests show pole or arm will fail before Rivnuts.



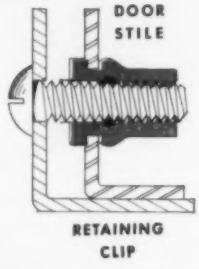
Clean, functional lines of modern *furniture* are preserved by Rivnuts. Upset inside tubular legs, they replace unsightly nuts, bolts and screws.



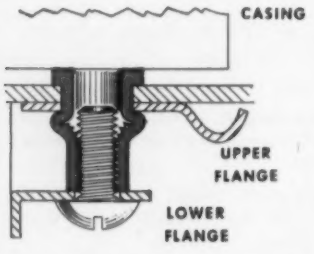
Rivnuts enable repair men to remove top of *automatic washer* and replace it easily. And Rivnuts can be installed after enamelling.



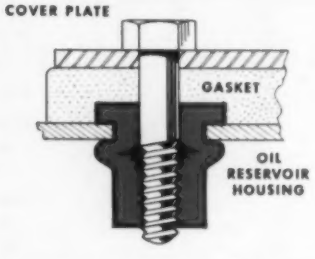
Upset Rivnuts secure *airplane window* plate to center post. Bulges in shanks seal out weather. Heads of Rivnuts serve as spacers for plastic window.



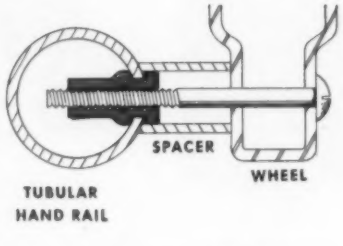
Rivnuts replace self-tapping screws used to hold retaining clips on aluminum *storm doors*, provide firm nutplates that won't loosen with shock or vibration.



Rivnuts eliminate need for reinforcing plates in *vaporizers*. In addition, Rivnuts space bottom flange automatically, prevent bending.



Assembly time for *oil reservoirs* is cut in half. Rivnuts eliminate welding, tapping and cleaning previously required to attach coverplate.



Wheel chair designers needed a blind nutplate with at least 6 clean threads. Rivnuts, only one-piece blind rivets with threads, were the answer.

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Thud! No crash, splatter, splash! But just plain thud! This bottle resists breakage because it's made of SUPER DYLAN® high density polyethylene. The gallon size weighs only 3½ ounces, yet it protects its contents . . . and the user, too! It's the bottle with the built-in bounce!

More than shatterproof, SUPER DYLAN bottles are rigid and light in weight—less than 1/10 the weight of gallon *glass* bottles. Needless to say, lightness like this cuts shipping expenses and simplifies handling.

Cost? Very economical. For sheer good looks you can just about name the color you want in SUPER DYLAN. Printability? It's easy by normal procedures.

SUPER DYLAN can be easily blow-molded into bottles of all sizes and shapes. You can use it to package almost anything. Acids, sure. Detergents, too; and cosmetics, pharmaceuticals, bulk chemicals, shampoos and food products. SUPER DYLAN resists heat and can be readily sterilized.

Write for more information on SUPER DYLAN high density polyethylene for bottles. Koppers Company, Inc., Plastics Division, Dept. PE-119, Pittsburgh 19, Pennsylvania.

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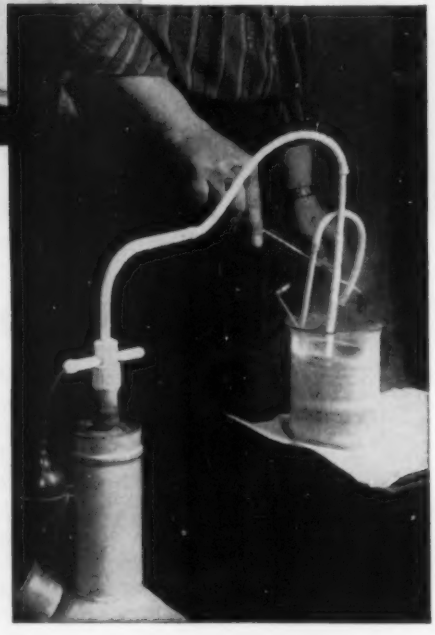
Physical tests at Standard include those for special properties of steel alloys under extreme variations in temperature. Here, the strength and ductility of steel are being checked for resistance to stress under severe conditions of elevated temperatures over a prolonged period of time.

Charpy impact and transition temperature determinations have recently assumed importance in many applications. Here a steel sample is immersed in liquid nitrogen to determine its susceptibility to fracture at temperatures as low as −300°F.



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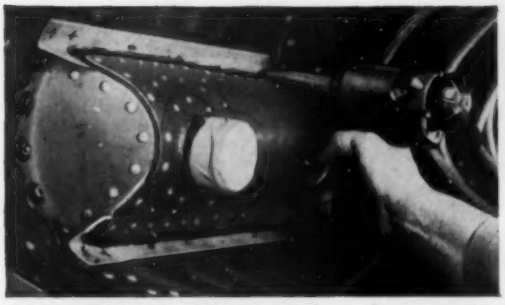

HEAT RESISTANT SEALING, such as shown on this Douglas DC-8 Jetliner, is made possible with RTV (room temperature vulcanizing) silicone rubber. RTV cures without application of heat; won't shrink (no solvents); forms no voids. It has excellent bond strength, plus resistance to high temperatures, moisture, weathering, ozone, aircraft fuels and solvents.

PRECISION MOLDING of prototype and engineering models and replacement parts is simplified and improved with RTV flexible mold material. G-E RTV's low shrinkage permits close tolerances and fine surface detail.

LOW-COST TOOLING with flexible RTV mold material offers added savings in time and expense. RTV's "built-in" release agent provides easy removal of this epoxy coil-winding form from mold. Total cost reduced 81%, delivery time 90%.

ENCAPSULATION OF STATOR WINDINGS, introduced by General Electric motor departments, extends service life of motors. RTV's resistance to moisture and other contaminants enables these dripproof motors to meet certain applications formerly requiring enclosed units.

POTTING OF AIRBORNE EQUIPMENT provides protection from high altitude arc-over and corona as well as vibration and moisture. RTV silicone rubber protects this cathode ray tube up to 70,000 feet.

RTV COIL IMPREGNATION enables this Hughes Aircraft Co. transformer to provide top performance at 250°. Unlike other insulations tried, G-E RTV compounds proved successful both for coil impregnation and full encapsulation.

For application data and samples of General Electric RTV silicone rubber write Section A1114, General Electric Company, Silicone Products Department, Waterford, New York

GENERAL ELECTRIC

CIRCLE 51 ON READER SERVICE CARD

Developing a motor-driven product?

Here's a Way to Make Sure You Get the Right Motor

When you reach the point in the development of a new product where you are ready to discuss the motor, we shall welcome an opportunity to carefully study your motor problem and try to find an existing motor design that will do the job.

If the *right* motor is readily and economically available, we shall tell you. Our interest is in devoting engineering man-hours to the solution of design problems—not in duplicating development work which already has been done.

Because of this approach and because of our motor design and development experience—44 years in the small motor field—we can help your company obtain the *right* motor . . . at the most favorable cost.

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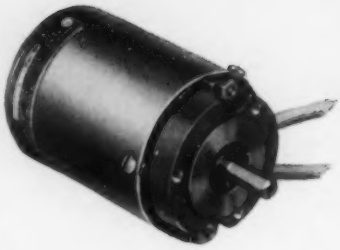
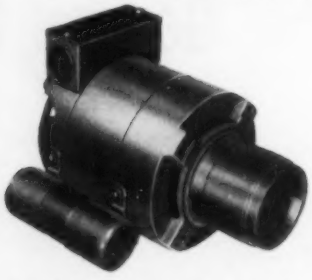
Lamb Electric

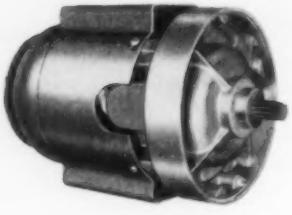
SPECIAL APPLICATION FRACTIONAL HORSEPOWER **MOTORS**



Lamb® six-pole 400 cycle AC motor for electronic cooling in missile control equipment. Frame 1 11/16 x 1¼.

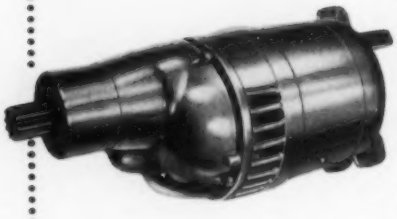


Lamb® four-pole capacitor start induction run motor with special bracket for telephone toll ticket process machine. Frame 4½ x 2¼.

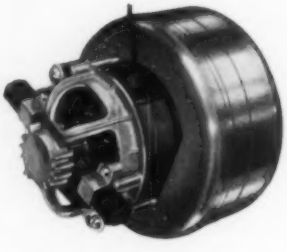


Lamb® totally enclosed fan-cooled explosion-proof motor for high pressure grease gun. Frame 3 11/16 x 2¼.

Write for your copy... 8-page folder describes these and other Lamb Electric motors.

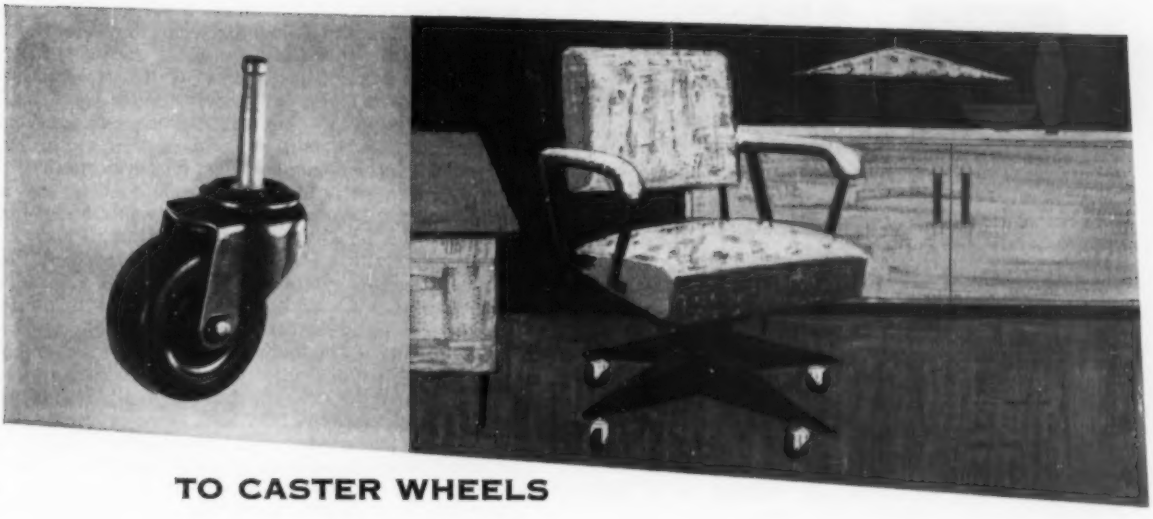


Lamb® heavy duty three-stage gearmotor for pipe threaders. Frame 4⅜ x 2¼.



Lamb® series motor with two-stage fan—the standard for high performance domestic canister-type cleaners.

FROM BABY JAR SEALS



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You name it—and your Firestone Technical Service Man will help you make it! He's accustomed to handling diverse production and design problems ranging from close-tolerance food seals to smooth-rolling caster wheels. He'll help meet *your* particular needs with a custom-tailored plan.

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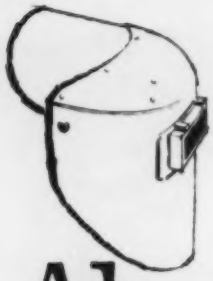

NO. 1 OF A SERIES

"How to Design Welded Aluminum Structures"

Alcoa Research in Strength of Welded

Mr. Harry N. Hill,
Engineering Design Division Chief, Alcoa Research Laboratories, Aluminum Company of America, reports research findings presented at the 1959 annual meeting of the American Society of Civil Engineers.

For the first time in the industry, Alcoa is publishing an informational series of new concepts in the strength and characteristics of welded aluminum. This new approach to the design problem is based on extensive, continuing investigation at Alcoa Research Laboratories where advanced methods for the use of aluminum structures are being explored.

As you well know, welding heat-treated or work-hardened alloys creates a somewhat weaker "heat-affected zone" in the immediate vicinity of the weld. Outside this narrow region the original high strength of the parent metal is unaffected. Previous design methods, using the old "weakest link" theory, required designers to use the *minimum strength* of the material in the heat-affected zone as the over-all strength of the structural member.

Alcoa research engineers have developed new design rules that far more accurately reflect the *actual strengths* of welded structures of aluminum. A new "reduced-strength zone" concept is used in these new rules. This zone is smaller than the heat-affected zone, as shown in the accompanying graph.

In a member containing a longitudinal weld, *all* the area within the reduced-strength zone is considered to have the minimum strength of the material adjacent to the weld. Beyond this zone, the aluminum is considered to have its original strength unaffected by the heat. *The ultimate or yield strength of such a member is calculated as the weighted average of the strength within the "reduced-strength zone" and that of the metal outside this zone.* Frequently, the reduced-strength zone constitutes but a small part of the total cross section, and the welding has a negligible effect on the strength of the member. This reduced-strength zone concept also applies to transverse and other localized welds. Subsequent articles in this series will treat these welds.

The validity of this new weld strength concept and the resulting design methods have been thoroughly demonstrated by tests of welded members in tension, compression and bending.

The extent of the reduced-strength zone has been exhaustively studied in surveys of hardness, tensile strength and yield strength. Careful analysis of a large body of such data with welded samples up to 2 in. thick has indicated the inert gas, tungsten arc or consumable electrode welding process does not create a reduced-strength zone in excess of 1½ in. from the center line of a butt weld or from the heel of a fillet weld. Experimental repair welds where the weld was chipped out and rewelded as many as *six times* were included in the data. The data indicated that for many welding conditions, the reduced-strength zone is substantially less than the maximum 1½ in. Here, appropriate smaller values can be used for design.

Watch for additional subjects in this series: 10-in. gage length yield strength; strength of welded members in tension; strength of welded members in compression; welded beams; fillet welds and design data.

Call your Alcoa sales engineer for detailed information on "Designing Welded Aluminum Structures," or write Aluminum Company of America, 1760-L Alcoa Building, Pittsburgh 19, Pa.

Your Guide to the Best in Aluminum Value

ALCOA ALUMINUM

ALUMINUM COMPANY OF AMERICA

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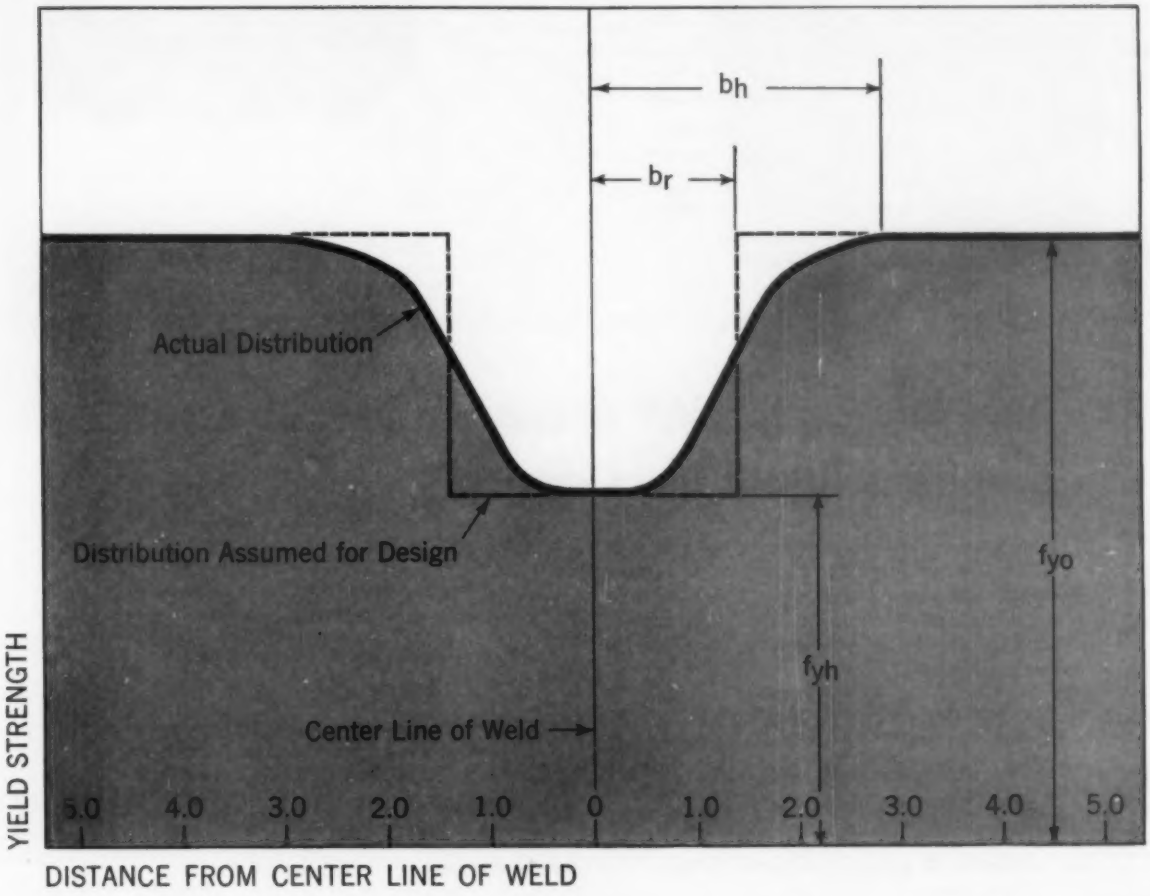
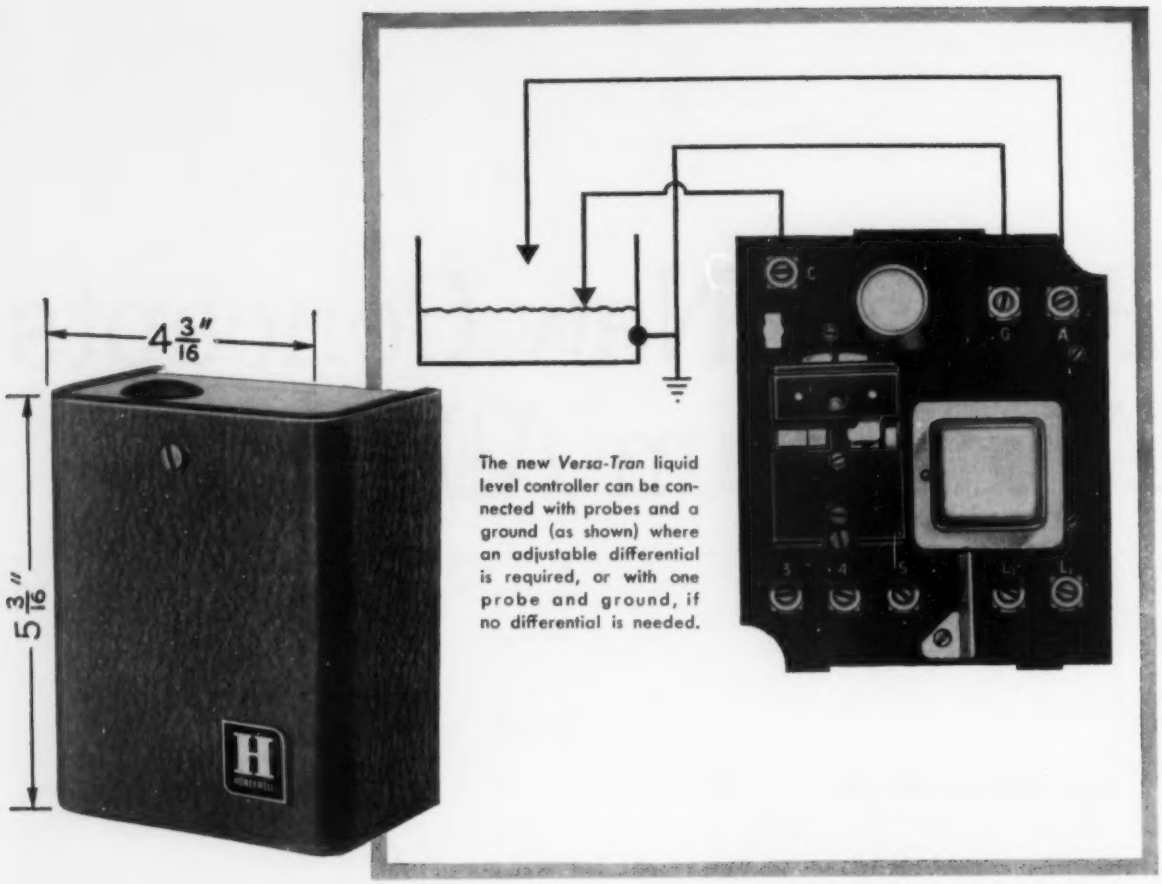
Reveals New Concepts Aluminum Alloys



Typical Distribution of Yield Strength Values in Vicinity of Weld

f_{yo} = Yield strength of parent metal unaffected by heat
f_{yh} = Minimum yield strength in heat-affected zone
b_r = Extent of reduced-strength zone
b_h = Extent of heat-affected zone



The new *Versa-Tran* liquid level controller can be connected with probes and a ground (as shown) where an adjustable differential is required, or with one probe and ground, if no differential is needed.

New low cost, high precision VERSA-TRAN® simplifies liquid level control

Here's a simple, easily-installed electronic controller that accurately controls the level of any electrically conductive liquid with a measured impedance not exceeding 25,000 ohms, measured at the probe-type sensing element. Its features include:

- Unique, fully transistorized design which eliminates need for field adjustment and calibration.
- Choice of fixed or adjustable differential by use of either one or two probes.
- Wiring between relay and probes can be ordinary 18 gauge, 2-conductor cable.
- No floats or standpipes necessary.
- Relay can be flush mounted, surface mounted or mounted in most electrical enclosures.
- All components zinc-chromate treated for corrosion resistance.

Your nearby Honeywell field engineer can help you profitably apply the new *Versa-Tran* liquid level controller. Call him today . . . he's as near as your phone.

MINNEAPOLIS-HONEYWELL, Wayne and Windrim Avenues, Philadelphia 44, Pa.

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First in Control

interchangeable with all standard JIC cylinders

With the introduction of the ALL NEW T-J Squair Head, Tomkins-Johnson now offers industry the most complete design range of air and hydraulic cylinders. Presently available in bore diameters from 1½ to 8 inches, the T-J Squair Head is an interchangeable cylinder which produces maximum force and efficiency, with minimum pressures . . . and is also adaptable to the use of low pressure oil as the working medium. Write to The Tomkins-Johnson Co., Jackson, Michigan, for Bulletin #SQ 10-58 and complete details.

CHECK THESE 10 POINTS OF T-J SUPERIORITY

1 One Piece Piston

2 Hard Chrome Cylinder Bore and Piston Rods

3 High Tensile Steel Tie-Rods

4 Cushion Adjusting Screw, Externally Adjustable

5 New Super-Cushion for air, or Self-Aligning Master Seal for Oil (T-J Patents)

6 Solid Steel Heads and Mounting Plates Standard all Models

7 Port Design Allows Minimum Pressure Drop on Inlet or Outlet

8 Chevron Type, Self-Adjusting Rod Packing

9 Piloted Packing Gland–Absolute Alignment

10 Piston Rod, Extra Strong–Polished and Chrome Plated for Efficiency and Protection

T-J TOMKINS-JOHNSON

ORCO

"Customeered" components basic to industry

ideas on "Customeered"

RUBBER PARTS

...their design and application for improved product performance No. 2

8-ft. rubber-metal "sandwich" resists chewing by weather, oil and millions of vehicles

Bonded-rubber component assures higher accuracy, longer operating life of vehicle detector contact unit

Pressure-sensitive detectors installed flush with roadway surfaces are vital factors in today's ever expanding vehicular world—are used for traffic control, toll collection, automatic door opening, etc.

A contact unit produced from molded-rubber bonded to heavy-gauge and thin-gauge metal strips serves as an actuator in the detectors. The pressure of a vehicle passing over the contact unit mounted on a steel frame below the surface of the road puts the detector to work—initiates a count or any specific action the detector is designed to perform.

The requirements for the sandwich-like bonded-rubber component comprising the contact unit: A completely waterproof and airtight air space within the full length of the one-foot wide units produced in varying lengths of four, six, eight and ten feet; resistance to the harmful effects of constant exposure to weather, sunlight, salt, oil and tire chains; an operating life involving a minimum of many millions of crossings by all types of vehicles.

The resulting design involved an exceptionally difficult molding and bonding job. Included were combinations of hard and soft rubbers. Careful attention had to be paid to many important and minute details of production and intricate design not only to meet the customer's stringent requirements for longer operating life but also to make good on rigid PSI specifications.

Ohio Rubber's wide and varied experience in "customeering"* to unusual specifications, as well as its broad, up-to-the-minute manufacturing facilities, were both equal to the challenge—successfully met all the requirements. The bonded, molded-rubber contact units are in regular production at Ohio Rubber.

PHOTO COURTESY AUTOMATIC SIGNAL DIVISION, EASTERN INDUSTRIES, INC.

MOLDED-RUBBER TUBE STORES AND PUMPS CLEANING FLUIDS

A most important part in the new Swirl-away Cleaner for walls, upholstery, woodwork, etc. is a molded-rubber tube which serves both as a secondary storage tank and vacuum pump for cleaning fluid. Unusual in shape and requirements the tube involved a complicated mold, close tolerances, and a control rate stock with particularly high resistance to harsh chemicals normally found in detergents. Problems on the design and production of this intricate rubber component were successfully worked out by engineers at Ohio Rubber where the part is now produced.

RUBBER-METAL PUMP IS KEY TO NEW DISHWASHER FEATURE

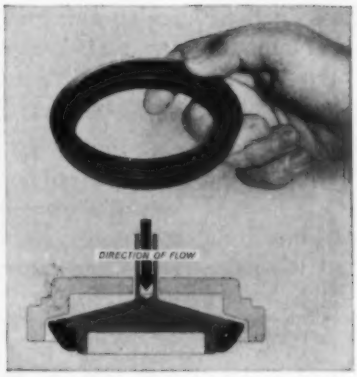
A vital component in a dual action pump which makes possible a "flush-away drain" feature in the dishwashers of a leading manufacturer, is a rubber-metal housing. Since rubber was required at several points for sealing and vibration absorption, the manufacturer asked Ohio Rubber engineers for help in designing and producing a pump housing of molded rubber bonded to a carbon-steel frame or insert. The material in the housing, which is in regular production at Ohio Rubber, also fully protects the frame from corrosive effects of both water and detergents.

THERE ARE MANY MORE EXAMPLES

of how Ohio Rubber "Customeered"* components are helping to improve product performance for outstanding original equipment manufacturers in every industry. For more information on Ohio Rubber "Customeering"*—molding, extruding, bonding-to-metal—with rubber, synthetic rubber, silicone rubber, polyurethane and flexible vinyl, write today to The Ohio Rubber Company, Willoughby, Ohio. 9DE2

**Trademarks of The Ohio Rubber Company*

Sewer-Pipe Seal – Precision extrusion of high specification rubber by ORCO provides an effective new approach for obtaining sealed or "premium joints" in sewage disposal lines—prevents surface water infiltration to reduce treatment costs. Available in a wide range of popular sizes, plus close tolerances, for concrete as well as clay pipe.



Orthane Valve Seat – Durable as the hardest steel yet resilient enough for sealing, this valve seat of molded polyurethane by ORCO is used in specialized oil field operations where it must successfully withstand the highly abrasive impact of raw crude oil mixed with gravel at pressures which often go as high as 20,000 PSI.

THE OHIO RUBBER COMPANY

Willoughby, Ohio

ORCO

A DIVISION OF THE EAGLE PICHER COMPANY

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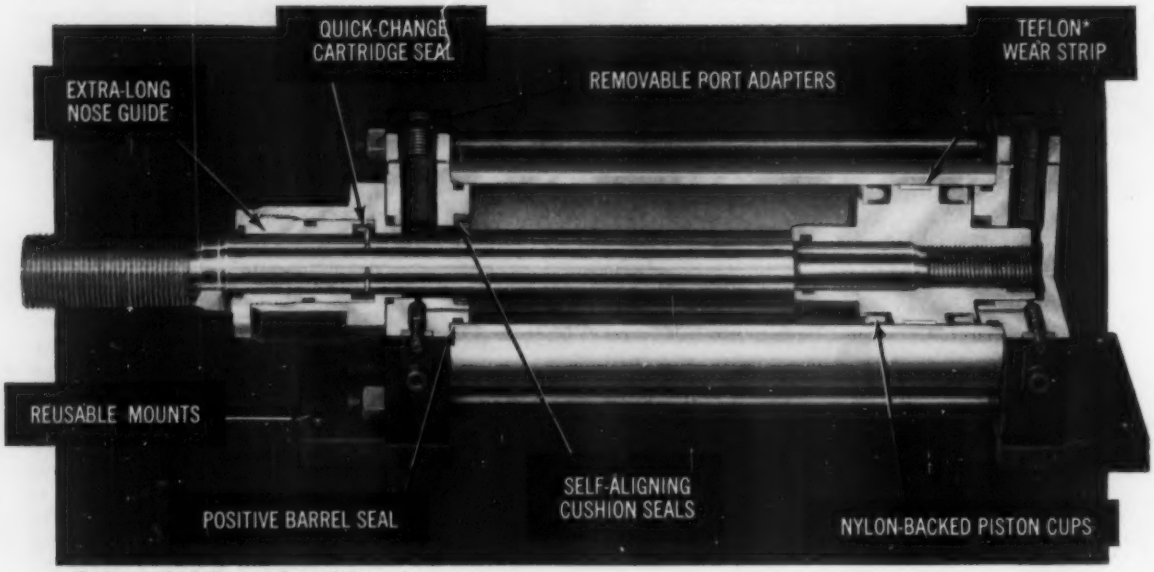
200 psi air, 500 psi hydraulic



*Trade name for Du Pont tetrafluoroethylene resin

. . . will provide efficient, dependable service on your high-production equipment

A look inside shows you why Valvair heavy-duty cylinders belong on *your* high-production machines! Built by Valvair, makers of famous SPEED KING valves, these heavy-duty cylinders provide design, construction and component material features coordinated to assure efficient operation, longest service life and minimum downtime.

Whether you're ordering new machines, or modernizing equipment now in use, it'll pay you to specify Valvair heavy-duty cylinders for all your high-production machines. A full range of bore and rod sizes, interchangeable *and reusable* mountings, stroke lengths and cushioning options are available.

Call in your nearby Valvair or Bellows field engineer today . . . take advantage of one-source responsibility for all your control system needs . . . cylinders, valves, manifolds, filters, regulators and lubricators.

8038-1

For detailed information, write for Bulletin VC-800. Address Dept. PE-1159, Valvair Corporation, Akron 11, Ohio

Offices in principal cities

Valvair AKRON 11, OHIO

DIVISION OF INTERNATIONAL BASIC ECONOMY CORPORATION (IBEC)

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HI-SPEED INLINE VALVES • PILOT VALVES • MINI-KING VALVES • MANUAL VALVES • FILTERS • REGULATORS • LUBRICATORS

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Save time everytime you refer to drawings, everytime you make prints

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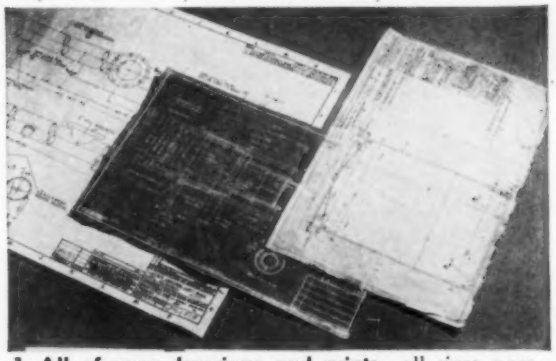

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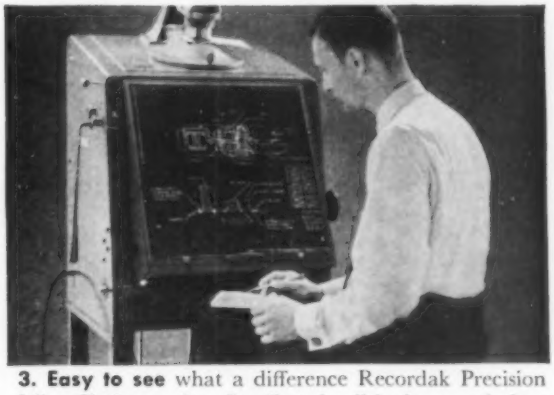

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Free booklet—"must reading" for every engineer and draftsman—gives further details on this new system, available through Recordak.

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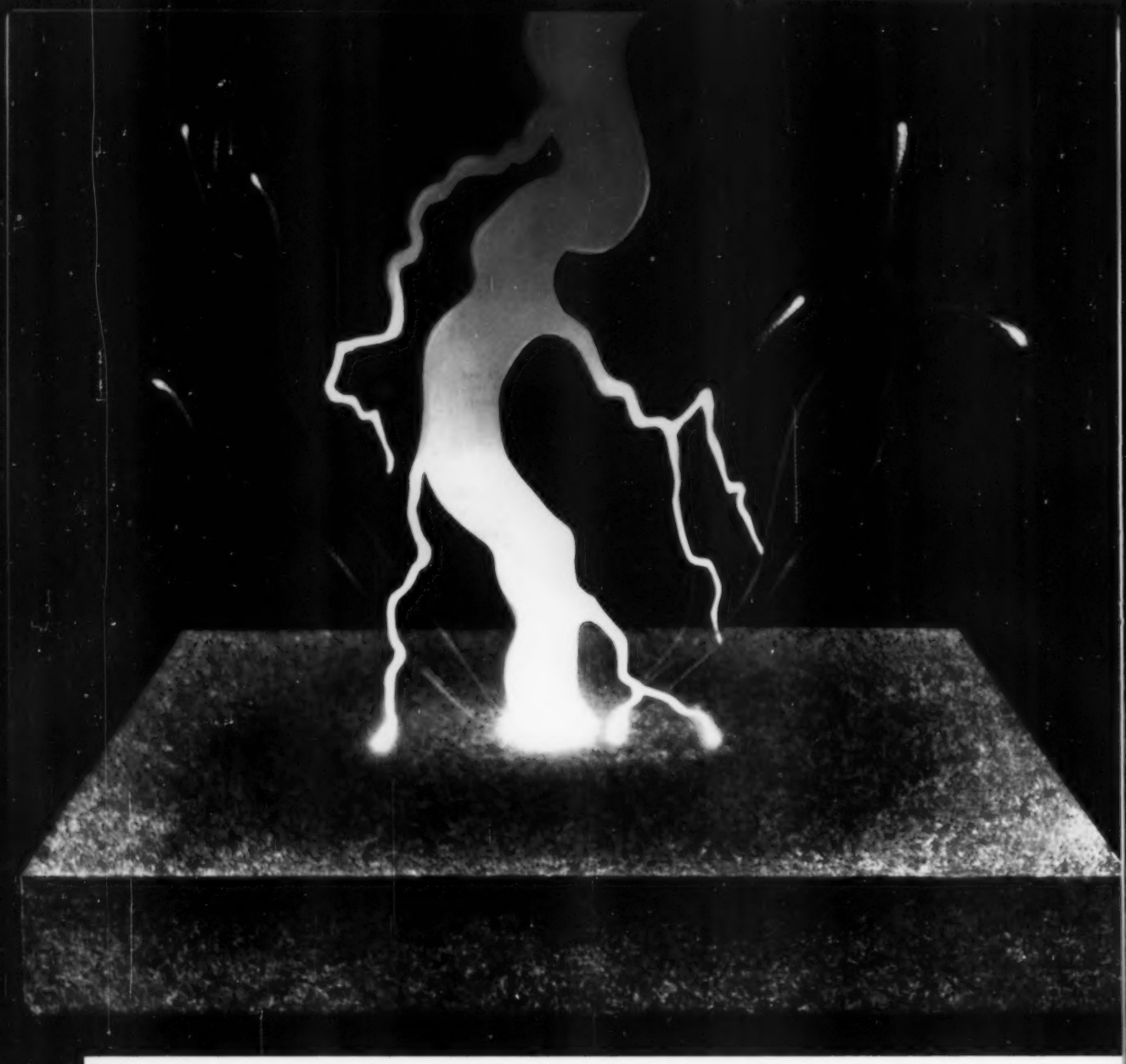

High voltage "lightning" discharge at a Malleable test block.

Toughness is Malleable

Under the slamming, bruising strain of a bulldozer's roughshod ride . . . inside the battering air hammer . . . against the repetitive concussion of a machine gun's smashing action . . . wherever conditions are really brutal, Malleable iron castings prove their ruggedness.

When you're looking for toughness, it will pay you to investigate Malleable castings. Contact one of the progressive firms that displays this symbol—

MEMBER
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CASTINGS COUNCIL

If you wish, you may inquire direct to the Malleable Castings Council, Union Commerce Building, Cleveland 14, Ohio, for information.

New Malleable Irons Meet Gruelling Service Tests

Toughness is a vital requirement in stressed parts. Each application, however, requires a particular combination of physical characteristics to be sufficiently "tough."

Whatever the specific requirements, one of the finest groups of materials available is the Malleable irons, as illustrated in the tables below.

Tensile Properties—A.S.T.M. Minimum Specifications
Standard and Pearlitic Malleable Irons

Designation	Tensile Strength p.s.i.	Yield Strength p.s.i.	Elongation % in 2 in.	Designation	Tensile Strength p.s.i.	Yield Strength p.s.i.	Elongation % in 2 in.
Standard				53004	80,000	53,000	4
35018	53,000	35,000	18	60003	80,000	60,000	3
32510	50,000	32,500	10	80002	100,000	80,000	2
Pearlitic							
45010	65,000	45,000	10				
45007	68,000	45,000	7				
48004	70,000	48,000	4				
50007	75,000	50,000	7				

Strengths up to 135,000 p.s.i. tensile and 110,000 p.s.i. yield are produced commercially under individual producers' specifications.

Other Mechanical Properties
Standard and Pearlitic Malleable Irons

	Standard	*Pearlitic*
Modulus of Elasticity in Tension, p.s.i.	25,000,000	26,000,000—28,000,000
Ratio of Fatigue Strength to Tensile Strength	0.54	0.40—0.50
Shear Strength—% of Tensile Strength	80—90%	70—85%
Torsional Strength	Approximately equal to Tensile Strength	
Compressive Strength, p.s.i.	200,000	250,000

Malleable's toughness is illustrated in a severe test conducted by a manufacturer of cab-over-engine trucks. To be absolutely sure of the strength and toughness of a variety of components in the cab, including the critical Malleable iron cab support hinges, a truck was crashed at high speed into a barricade of ice. Result—no hinge damage, even though the truck was seriously battered.

Service-Demonstrated Toughness

Highway railing posts demonstrate Malleable castings' use where impact resistance is critical. As an example, thousands of Malleable railing posts line the Connecticut State Thruway. The State Highway Department reports that there have been no failures of the Malleable iron posts although other materials have failed in several cases.

It is also because of Malleable's toughness that so many of the highest quality hand tools are made of Malleable iron. One leading tool manufacturer tests the quality of its pipe wrenches by using a trick well known as the best way to break a wrench. The wrench jaws are put on a rigid bar, a long pipe is slipped on the handle, and the tester heaves his weight downward on the pipe. Because of their confidence in Malleable's toughness, this company unconditionally guarantees every Malleable wrench housing against distortion and breakage. Another hardware manufacturer makes a similar guarantee against breakage on its line of Malleable vises.

But Malleable iron's proven performance in field service is only one reason for its wide use. To this, you must add Malleable's low first cost, design flexibility, and excellent machinability. This combination offers unique advantages over other metals.

Design and Production Assistance Available

To assist in the use of Malleable castings, a special bulletin on toughness—Data Unit No. 105—is available from the Malleable Castings Council, Union Commerce Building, Cleveland 14, O. These bulletins and engineering and planning assistance are also readily available to you from any member of the Malleable Castings Council.

These companies are members of the

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Eastern Malleable Iron Co., Naugatuck
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MICHIGAN
Albion Malleable Iron Co., Albion
Auto Specialties Mfg. Co., Saint Joseph
Cadillac Malleable Iron Co., Cadillac
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NEW HAMPSHIRE
Laconia Malleable Iron Co., Laconia

NEW JERSEY
Meeker Foundry Company, Newark 4

NEW YORK
Acme Steel & Mall. Iron Works, Buffalo 7
Frazer & Jones Company Division Eastern Malleable Iron Co., Solvay
Oriskany Malleable Iron Co., Inc., Oriskany
Westmoreland Mall. Iron Co., Westmoreland

OHIO
American Malleable Castings Co., Marion
Canton Malleable Iron Co., Canton 5
Central Fdry. Div., Gen. Motors, Defiance
Dayton Mall. Iron Co., Ironton Div., Ironton
Dayton Mall. Iron Co., Ohio Mall. Div., Columbus 16
Maumee Malleable Castings Co., Toledo 5
National Mall. and Steel Castings Co., Cleveland 6

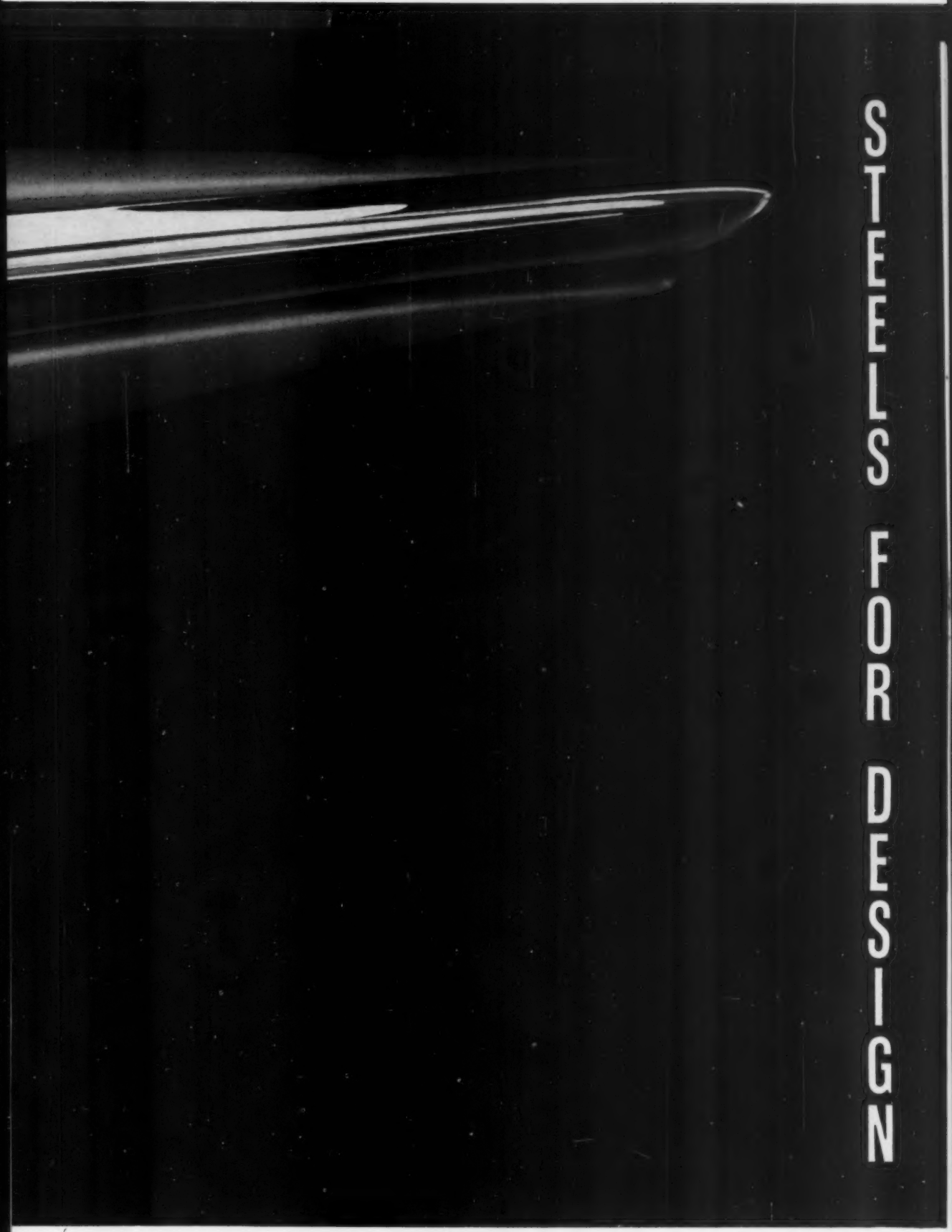
PENNSYLVANIA
Buck Iron Company, Inc., Philadelphia 22
Erie Malleable Iron Co., Erie
Lancaster Malleable Castings Co., Lancaster
Lehigh Foundries Company, Easton
Meadville Malleable Iron Co., Meadville
Pennsylvania Malleable Iron Corp., Lancaster

TEXAS
Texas Foundries, Inc., Lufkin

WEST VIRGINIA
West Virginia Mall. Iron Co., Point Pleasant

WISCONSIN
Belle City Malleable Iron Co., Racine
Chain Belt Company, Milwaukee 1
Federal Malleable Company Inc., West Allis 14
Kirsh Foundry Inc., Beaver Dam
Lakeside Malleable Castings Co., Racine
Milwaukee Malleable & Grey Iron Works, Milwaukee 46

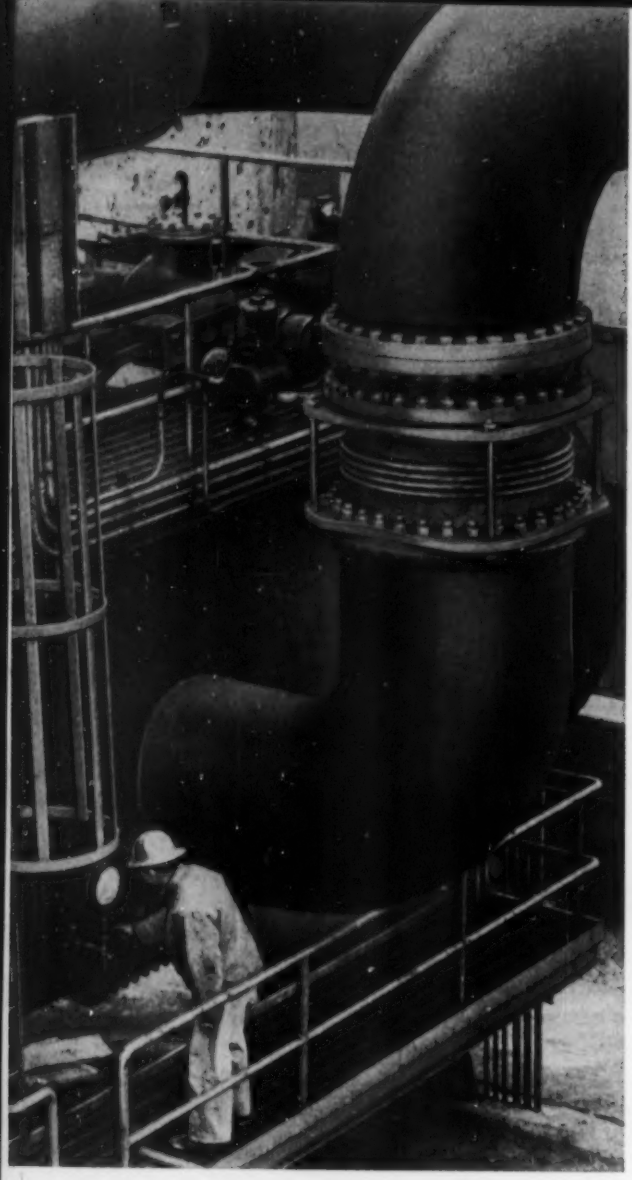
Form your own opinion A missile in flight? . . . A blacksmith's anvil? . . . The tail fin of an automobile?



STEELS FOR DESIGN

The "fin" is right—it is made of steel . . . ductile enough to stretch a point, yet strong enough to stand firm.

For some other formable examples of steel, turn the page ▷ ▷ ▷



Stainless Steel An expansion joint in a piping system absorbs movement which might otherwise result in reduced life or even complete destruction of vital equipment and piping. One of the best types is the flexible, corrugated Stainless Steel bellows type as manufactured by Zallea Brothers of Wilmington, Delaware.

To produce these bellows, a sheet of Stainless Steel is rolled into a cylinder and welded lengthwise by special automatic equipment. This cylinder is then formed within steel dies by imposing internal hydraulic pressures as high as 4500 psi while compressing the cylinder. The smoothly shaped, cold formed bellows which results are capable of absorbing many cycles of compression, extension, rotation or lateral deflection. Because the bellows are Stainless Steel, they are corrosion resistant, maintenance-free, and capable of prolonged service under severe temperature and pressure conditions.

USS "T-1" Steel Shaped like a giant seashell, a turbine scroll case must withstand tremendous pressure. Water gushes through the conch in an ever-tightening spiral before shooting into the blades. Chicago Bridge & Iron Company used USS "T-1" Constructional Alloy Steel for the shells of four of the largest scroll cases in the Noxon Rapids Dam in Montana. Because of the exceptional strength of "T-1" Steel—115,000 psi minimum tensile strength—the walls could be made nearly 50% thinner and 50% lighter than carbon steel walls. Freight costs were lower. And because there was considerably less weight, the foundations for the cases could be made lighter and less expensive.

USS MAN-TEN High-Strength Steel Manufacturers have turned to high-strength steels to increase the strength of earthmovers without adding to their weight. LeTourneau-Westinghouse Company built their Model B scraper with USS MAN-TEN Low-Alloy High-Strength Steel in the yoke structure, side sheets, body truss tubes, and apron arms. MAN-TEN steel has a yield point of 50,000 psi—about 50% higher than carbon steel. This extra strength also permits designs with thinner, lighter sections that can reduce weight as much as 1/3 with no loss of strength. And though MAN-TEN steel is exceptionally strong, it is not difficult to form. In fact, MAN-TEN steel frequently simplifies fabrication because it can be used in lighter gages.

USS, MAN-TEN, and "T-1" are registered trademarks

STEELS FOR DESIGN

United States Steel USS

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Product Engineering

HORIZONS

November 9, 1959

DEAD-END DESIGN

A German designer told me once that there are three stages in mechanizing a hand process:

Stage One: Evolve hand-like components to perform the operation faster and flawlessly. This stage dead-ends when the maximum speed or strength of a hand-like mechanism is attained. This kind of development requires only ingenuity, can often be done by a skilled mechanic.

Stage Two: Evolve an efficient mechanism to do the desired work in some other way. This stage dead-ends when the speed or strength limit of the new mechanism is reached. Here inventiveness has been added to ingenuity, so some design knowledge is required.

Stage Three: Evolve a new process to achieve the same end more economically or efficiently, developing machine and product simultaneously. The dead end here is far out, because a new field of development has been opened. Creativity has been added to inventiveness.

All this comes back as we watch the argument over nuclear-propelled aircraft. Most service officers want to build a plane now, with a rudimentary engine. But Dr Herbert York of the Defense Dept, in opposing this proposal to build and rebuild, testified: "Many of the results and much of the experience which would be obtained from a premature flight using interim results and possibly dead-end design are very likely to be erroneous and misleading . . . The powerplant using the available materials has little or no growth potential . . ."

There it is, in simple language: Shall we go into hardware now to "get experience," win a propaganda round, build and rebuild—or shall we wait to perfect a design, probably missing some working experience and our chance to be "first" in the air while we search and research?

Part of the answer in any given situation may lie in that last word. Too often, "research" is considered to mean only the forward look. But the word itself suggests something else; "re-search" implies a going-back to recheck and resurvey, to find what "laws" are not laws but outmoded theories, what basic errors there may be upon which we've built a house of cards.

In the particular case cited, we have another example of the repeated tug-of-war between the scientist who wants to perfect the idea and the engineer who wants hardware, the engineer who wants a production design and the management man who wants a product and a profit, the inventor with an idea and the entrepreneur with an investment.

Rarely is there a simple answer to the problem. Usually a compromise must be reached between the search for perfection and the urge to produce a design that may be dead-ended by further search. We see it in the companies trying to convert extensive R & D setups into a profit rather than an expensive hobby, the stockholders who want products to sell now not better ones to sell tomorrow.

There is no perfection in design; the major question is how much perfection can be permitted—how soon the dead end will be reached. Time was when progress was willing to accept orderly development through the German designer's three stages, but now the effort seems to be to skip the first two, and to do the third at the speed of the first. The past must be re-searched, for another miracle today.

THESE MACHINES

grind, scratch, gouge, to measure

Abrasion resistance can't be predicted from known properties of a material. Even testing is unreliable unless test conditions are closely related to actual conditions the material will see in service. Here are a group of machines that simulate such conditions and give comparative data quickly and inexpensively.

DONALD GARDNER, *manager*
Materials and Chemistry Dept
US Testing Co Inc

Taber Abraser . . . rotates sample on turntable under two abrasive wheels. When hinged arm is lowered so that wheels rest on test surface, axis of wheels does not intersect that of turntable but is displaced slightly to the rear. This results in a more vigorous grinding action. Load can be adjusted by adding or removing weights on arm.

Which will wear out first: a bearing made of cast iron or one made of aluminum? The handbook of materials properties shows the lightweight metal is, in general, somewhat harder than the cast iron. On the other hand, it shows cast iron has a lower coefficient of friction. Are these properties related to wear resistance?

The answer is both yes and no. Abrasion resistance depends on service conditions. This can be seen by comparing tool steel and rubber. Certainly the steel will outwear rubber in many applications, but under a jet of abrasive particles, the same metal will erode badly and the rubber is almost unaffected. Another comparison: Teflon has a lower coefficient of friction than nylon, but if you scrub the two materials over a polished metal surface, the Teflon shows wear faster.

Intuition might have predicted this, but the only sure way to compare abrasion resistance of two materials is to subject them to the expected abrasive conditions and measure the results. That's why abrasion-testing machines are a part of any well-equipped materials-testing lab. They simulate service conditions on a small scale, give comparative results quickly and inexpensively.

THE NATURE OF SURFACE ABRASION

Abrasion tests are practical for both hard and soft materials. All materials from paper to carbide have been tested for abrasion resistance at one time or another. Sometimes it is just as important to find a material that will wear down as it is to find one that will not. Mating parts of many machines, for example, rely on "controlled" wear to achieve a smooth-running fit.

Surface abrasion is caused by mechanically over-stressing of the surface of the material. The other type—internal abrasion—is characteristic of fiberous materials Such abrasion results from excessive internal stresses caused by the abradant and does not interest the product designer enough to be discussed here.

There are three classes of surface abrasion: grinding, scratching, gouging. Grinding and scratching both wear away the material by rubbing an abrasive against it. The difference is primarily in the applied load; grinding implies high stresses, scratching implies lower stresses and is characterized by an erosion or impact process. The third class, gouging, is similar to the cutting action of a tool bit, and can be best described by visualizing the action of a weighted stylus passing back and forth over the material sample.

CHOOSING A STANDARD TESTER

The six testers shown in photos on these pages encompass all three classes of surface abrasion:

Grinding—Taber Abraser
US Testing Company Abrader
Universal Wear Tester
Multimotion Abrader
Scratching—Bell Labs Abrasiometer
Gouging and grinding—Bureau of Standards Field Abrader

But the goal in designing the machines was not so much to isolate the three categories as to reproduce the abrasive action of common service conditions. All these machines are available from many commercial suppliers

abrasive wear

Universal Wear Tester . . .
is a multipurpose machine for measuring abrasion resistance of plastic films, rubber sheeting, leather, paper and fabrics. Standard abrasive (sandpaper, emery cloth, etc.) is clamped in platen above the sliding platform that holds sample. Machine can be rigged to stop when depth of abrasion has reached a predetermined point.

Bell Lab Abrasiometer . . .
works like a small sand-blaster. A measured quantity of abrasive particles is driven against the surface of the specimen by a high-velocity air jet. Sample is usually positioned with respect to the jet so that grit blast impinges at angle of 45°.

US Testing Co Abrader . . .
simulates a back-and-forth grinding action. Here, sample is placed on the carriage and abrasive on the arm, but positions of sample and abrasive can be reversed. This versatile instrument will take a variety of abradants, or can be modified so sample is immersed in water.

Multimotion Abrasion Tester . . .
was designed by US Testing Co to test fabrics and other flexible materials. Specimen is stretched over disk in upper arm and abrasive rotates on turntable underneath. Friction rotates the disk giving a circular grinding action.

Bureau of Standards Field Abrader . . .
was designed to measure gouging and grinding resistance of stone floor-tiles, can test other similar materials. Abrasive is stored in hopper and ducted under the grooved wheel, which rotates at fixed rpm.

of scientific instruments. Cost ranges from $500 to $3000.

Although these are probably the most common and representative machines, they are not the only ones available—there are dozens of recognized general-purpose testers and many more custom-built machines designed to reproduce one-of-a-kind service conditions. Most machines, however, are similar except for the details of abrasive action. Machines that abrade by grinding, for example, may differ in the motion of the abradant over the sample (some move back and forth, others in a circular path) or in the applied load, but all move some kind of abrasive over the test surface.

The choice of testing machine will, of course, depend on the expected service conditions. Analyzing the wearing action the material will see in service, and picking a machine that best duplicates this action, requires experience and ingenuity. Keep in mind that many of the machines have much broader applications than were originally intended in their design. Moreover, an adequate measure of abrasion resistance often requires more than one machine—a battery of tests is necessary to get data that properly corresponds with all aspects of service conditions.

After the tests have been performed, how do you decide which material stands up best? There are several ways. The amount of material removed can be measured by weighing the sample before and after, or by measuring thickness. For harder materials or tests run off quickly, loss in gloss or loss in reflectance also indicates the amount of material that has been removed.

TYPICAL ABRASION DATA

Here is a hypothetical problem: In designing a bushing for a piece of test apparatus, an engineer has a choice to make among seven plastics—these are candidates that satisfy requirements from every standpoint except abrasion resistance. Now he wants to find which bushing material will be least affected by abrasive wear.

The Tests

Because of the nature of the abrasive action, he chooses five testers: (1) Multimotion Abrader (sample dry); (2) Multimotion Abrader (sample wet); (3) Taber Abraser (sample dry); (4) Taber Abraser (sample wet); (5) Bell Laboratories Abrasiometer.

Wear on the Taber samples is measured by weighing before and after; the Multimotion samples are compared by measuring loss of gloss while Bell samples are compared by measuring gloss retention. Here are the results:

Material	Test 1	Test 2	Test 3	Test 4	Test 5
A	53.4%	52.1%	16.0 mg	18.0 mg	80.1%
B	52.1	49.2	14.0	17.2	75.2
C	55.0	53.2	6.1	8.4	71.4
D	68.0	66.4	46.6	48.1	78.0
E	74.0	73.2	19.2	21.4	68.1
F	61.0	59.1	44.1	49.2	53.5
G	48.0	47.2	8.6	9.9	69.2

Cumulative results can be best compared by assigning numerical ratings to each sample in each test. The best material is assigned a value of 100, the next best, a value of 90, the next, 80, and so on down the line. There is no attempt to assign values in proportion to the test readings because such a rating system is too complex. Comparative values for each material are found by totaling assigned ratings. Material A, for example, ranks third, third, fourth, fourth and first in these five tests so its total is 80 + 80 + 70 + 70 + 100 = 400.

The Rating

This assumes each test is of equal importance. But many times it is evident that one test is more representative of service conditions and should be given more influence in the final total. In this comparison of bush-

AN ABRADER IS TAILORED TO THE JOB

SIEFAR BORTAS
Bell Telephone Laboratories
Murray Hill, NJ

■ General-purpose abrasion testers aren't always adequate—they only approximate service wear. On the other hand, a custom-built machine will give an exact duplication of service conditions. It's usually more expensive and time-consuming this way, but data is more reliable.

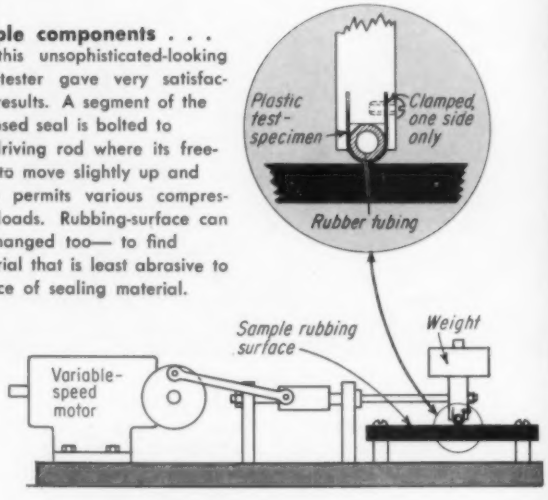
Bell Labs chose the custom-built way when faced with the problem of choosing a wear-resistant material for a sliding, low-pressure air seal. The testing machine was put together from standard hardware (sketch at right), most of it commercially available or easily fabricated. Tests on this machine, in runs over a period of two weeks, gave comparative wear characteristics of several different combinations of materials rubbed one against the other, in a manner closely approximating service conditions.

No abrasion data available

The problem arose when designing a machine that has a series of trays sliding on tracks underneath a flat plate. In operation, trays move back and forth, stopping momentarily in certain positions before moving to next position. To keep out dust and dirt, there is a slight positive pressure inside each tray, and a seal on the upper lip of the trays. This seal rides against the underside of the plate.

Design needed a sealing material that would not shed small paricles into the tray as it moved, but flexible enough so that the

Simple components . . . but this unsophisticated-looking wear-tester gave very satisfactory results. A segment of the proposed seal is bolted to the driving rod where its freedom to move slightly up and down permits various compression loads. Rubbing-surface can be changed too— to find material that is least abrasive to surface of sealing material.



ing materials, it was felt that results of both wet and dry Taber abrasion tests (columns 3 and 4) are more meaningful than the others. Therefore, the best sample for these tests is assigned a value of 200 (instead of 100), the second best a value of 180, etc. Now the total for material A is: 80 + 80 + 140 + 140 + 100 = 540.

Summing all scores gives totals showing comparative rank of each material under the anticipated service conditions.

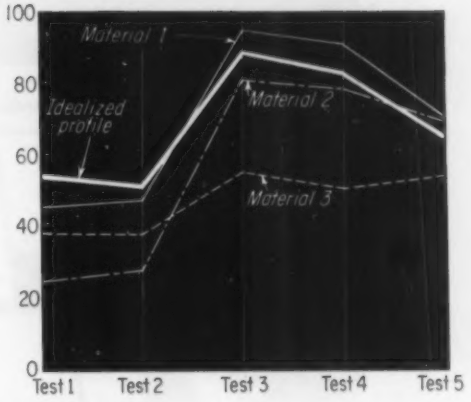
Material G	620	**Material A**	540
Material C	610	**Materials D & E**	370
Material B	580	**Material F**	340

The Conclusions

This is only a rough comparison, of course. Material G is not significantly better than material C—in fact, it may not even be as good in actual use. Errors were introduced when the tests were weighted, when ratings were assigned, and in the original test results. However, some conclusions can be made. Materials G, C, B, and A are significantly better than materials D, E, F. Also, materials G and C are probably somewhat superior to materials A and B.

Results can also be plotted to show comparative abrasion properties in a manner similar to that used to show results of a battery of personality tests. This "profile" forms a unique pattern for each material under test. High scores and low scores are not averaged out as before, but appear graphically on the chart.

Data plotted this way is of no particular value unless there is a reference profile against which individual profiles of each material can be compared. This idealized profile can be worked out one of two ways. It can be plotted by examining the abrasion-producing elements in the proposed end-use situation, or it can be taken from profile of materials that have been successful in the intended application. ■



Abrasion profile . . . is convenient way to rate results of several different abrasion tests. Comparing profiles of several samples with idealized profile helps pick best all-round material. This method is particularly handy for picking a material whose resistance to certain kinds of abrasion is low to allow for seating of mating parts.

EDITOR'S NOTE: For more about the destructive character of wear and abrasion—and how to avoid it—see:

Picking The Plastic For Abrasion Resistance, Mar 31 '58, p 105. A simple test and tabulated results give comparison between wear properties of several common plastics.

More Surface Polishing . . . Less Galling, Nov 24 '58, p 63. How to avoid seizing of mating parts caused by transfer of metal particles from one surface to the other.

Wear of Lubricated Surfaces, Apr 13 '59, p 74. A report on four papers given at this year's ASME Lubrication Symposium.

New Coefficients Predict Wear of Metal Parts, June 23 '58, p 71. Equations help the designer choose materials and configuration that will lengthen life of sliding parts.

65-in.-long seal could be compressed to sealing area $\frac{1}{32}$ in. wide with a load 125 lb or less.

A literature search and several phone calls failed to turn up any information concerning wear resistance of suitable materials, and a test program became necessary. The list of candidates was narrowed to materials at hand or immediately available: nylon Teflon and Mylar for the sealing material, and cold-rolled steel, stainless steel, aluminum, Lucite and Graphtung steel for the surface against which the seal rubs.

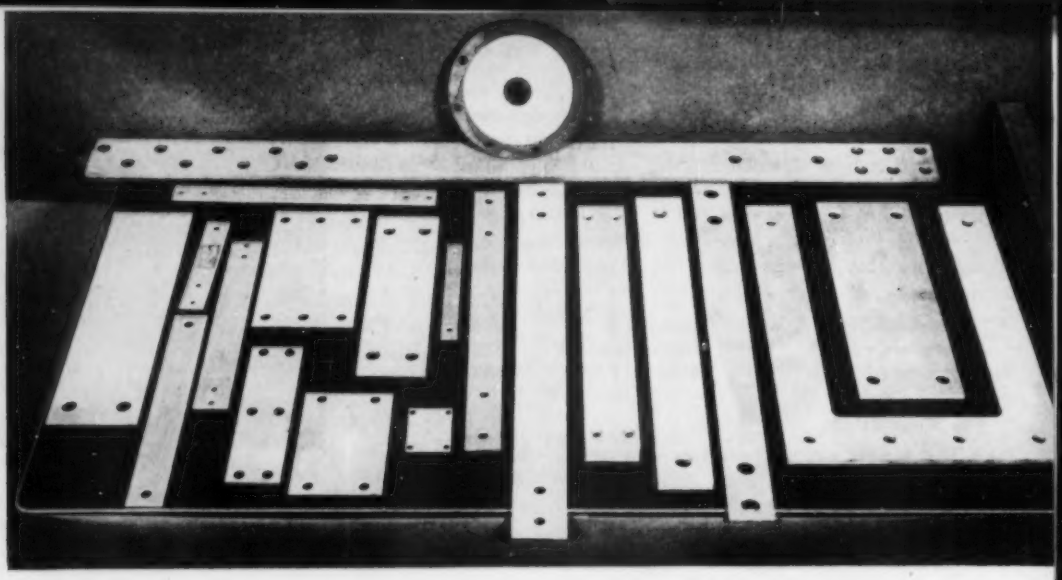
Because many plastics have a tendency to set when compressed for long periods, seals of this kind usually have a back-up spring—in this case, a piece of rubber surgical tubing, $\frac{1}{4}$ in. dia, 0.050-in. wall. A thin sheet of this plastic material is wrapped around the tubing to give the desired abrasion-resistant surface.

Test Conditions

To simulate service wear in the testing machine, a 2$\frac{1}{2}$-in.-long portion of seal and tubing was attached to the moving arm. Load on the arm depended on the force necessary to compress the seal to the required $\frac{1}{32}$-in width.

The arm had a travel of 2-in.—totaling 4 in. per cycle. Speed of the motor was on set at 120 rpm, approximately linear speed of the seal in the actual operation. Each metal plate had a surface finish of 4 microinches. Extent of wear was determined by measuring the plastic specimens at eight points and averaging. Results are in table at right. ■

Test Specimen (thickness in inches)	Rubbing Surface	Weight, lb	Wear factor, revolutions per mil wear
0.010 Teflon	2024 Aluminum	2	5,570
0.010 Teflon	Cold-rolled Steel	2	5,700
0.005 Nylon	Cold-rolled Steel	3	23,000
0.0048 Mylar	2024 Aluminum	3	29,100
0.0048 Mylar	Cold-rolled Steel	3	148,750
0.0048 Mylar	Lucite	3	24,000
0.0048 Mylar	18–8 Stainless	3	180,000
	(90° to rolling marks)		
Following Tests Performed Under Dust Shield			
0.010 Teflon	Graphtung Steel	3	6,630
0.0048 Mylar	18–8 Stainless	3	228,000
	(90° to rolling marks)		
0.0048 Mylar	18–8 Stainless	3	189,800
	(90° to rolling marks)		
0.0048 Mylar	Graphtung Steel	3	350,700



how to design . . .

FLAT REINFORCED-PLASTIC SPRINGS

Service experience shows that directionally reinforced epoxy laminates are more efficient than steel for many leaf-spring applications. Here's why, along with equations for calculating the critical stresses, and an example that shows the equations at work.

L A HEGGERNES, *Technical service engineer*
Reinforced Plastics Div, Minnesota Mining and Manufacturing Co

Glass-reinforced plastics are excellent energy absorbers and thus are receiving major attention in spring design. Sparking this interest are new techniques of putting the glass reinforcement where it's needed most (see *PE*—*July* 20, p 46, and Aug 17, p 60). Designers of vibratory leaf springs have taken advantage of one of these methods—compression molding of directionally reinforced, pre-impregnated (pre-preg) epoxy plastic. By molding a cantilever beam with up to 87% of its fibers in the bending direction, a leaf spring can be designed that is twice as efficient as a steel spring of equal stiffness.

Key to design of such epoxy-glass leaf springs as those pictured above lies in (1) understanding the material and its properties, and (2) analyzing the limiting stresses in any proposed design. This article explains the material as it applies to flat springs and presents the basic equations for stress analysis—with a step-by-step design procedure illustrated on the facing page.

Why Directional Reinforcement?

By coating glass rovings (loosely twisted bundles of glass fibers) with accurately metered, catalyzed epoxy resin, a nonwoven sheet or "ply" 48 in. wide x 8 mils thick is produced. Continuously manufactured like tape, this pre-preg sheet has its reinforcement all in one direction. In this uncured state, many yards of the sheet are rolled into large rolls as a source of individual plies for molded sheet stock. A typical ¼-in. leaf spring, for example, would have 30 plies after molding—24 of them core plies in the bending direction; 2 plies on each face at right angles, to provide needed cross strength; and 1 finishing ply per face in the flexing direction again.

Selectively orienting the glass reinforcement gives three basic types of molded sheet: unidirectional (fibers all one way), cross-plied (equal fibers at right angles), and isotropic (plies alternate 120° apart). When the stress direction is known, as in leaf springs, the strongest of these—unidirectional—is chosen. The properties of unidirectional shown in the accompanying table are for stock with 100% of the fibers in the flexing direction. With spring stock, the few cross-plies added to provide cross strength cut this percentage slightly, so that ulti-

(CONTINUED ON PAGE 76)

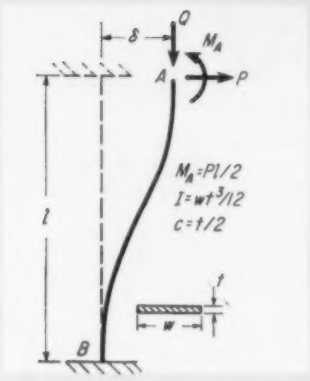
Spring Materials Compared at Room Temperature

Properties	65% Glass–35% Epoxy*			Flat Spring Steel (SAE 1060)
	Unidirectional	Cross-plied	Isotropic	
Ultimate flexure strength S, psi × 1000	113	90	66	180
Flexure modulus E, psi × 10^6	4.7	3.0	2.7	30
Volume efficiency n, in.-lb/cu in. (cantilever: $n = S^2/18E$)	151	135	90	60
Endurance limit, psi × 1000	29	22	15	33
Max design stress, psi × 1000	20	15	12	.....

*3M's "Scotchply," Type 1000

REPRINTED circle P20, inside back cover

STRESS EQUATIONS FOR CANTILEVER SPRINGS



Here are derived the basic equations needed for stress analysis of reinforced-plastic leaf springs. The adjacent sample problem shows how to apply them.

For bending stress:

$$M_B = Pl - Pl/2 + Q\delta = Pl/2 + Q\delta \quad (1)$$

$$\delta = P l^3/3EI - M l^2/2EI \quad (2)$$

then

$$P = 12EI\delta/l^3 = Ewt^3\delta/l^3 \quad (3)$$

thus

$$M_B = (6EI/l^2 + Q)\delta \quad (4)$$

then calculating bending stress $S_B = M_B c/I$

$$S_B = (3Et/l^2 + 6Q/wt^2)\delta$$

for min S_B, setting $dS_B/dt = 0$

$$dS_B/dt = 3E\delta/l^2 - 12Q\delta/wt^3 = 0$$

thus, optimum thickness t is

$$t = (4Q l^2/wE)^{1/3} \quad (6)$$

For equivalent stiffness:

From (2) above

$$\delta = Pl^3/Ewt^3$$

since equal stiffness means equal δ

$$Et^3(\text{plastic}) = nE_s t_s^3(\text{steel})$$

where n = no. leaves in steel spring thus, plastic thickness for equal stiffness is

$$t = t_s(nE_B/E)^{1/3} \quad (7)$$

For column buckling:

To prevent buckling, the following must hold,

$$Q/A \leq 4\pi^2 E/(l/r)^2 = S_{CR}$$

for rectangular beam

$$r = t/\sqrt{12}$$

thus

$$Q/A \leq \pi^2 Et^2/3l^2 = S_{CR} \quad (8)$$

STRESS ANALYSIS—A SAMPLE PROBLEM

A large shaker unit in a vibrating screen system is supported on a series of 6 steel leaf springs, each a cantilever 6 in. wide x 0.125 in. thick. How thick should a single epoxy-glass leaf spring of the same width be if it is to replace the composite steel spring? Design conditions: cantilever is 30 in. long with 24-in. free length; max deflection = 0.375 in.; axial load per spring = 2500 lb; a safety factor of 8 is specified; E = 4.5 x 10^6 psi; UFS = 100,000 psi.

Step 1: What thickness gives minimum bending stress?

From equation (6) at left:

$$t = (4 \times 2500 \times 24 \times 24/6 \times 4.5 \times 10^6)^{1/3}$$
$$t = 0.6 \text{ in.}$$

Step 2: Is the max combined stress below the allowable design stress?

From equation (5):

$$S_B = (3 \times 4.5 \times 10^6 \times 0.6/24 \times 24 + 6 \times 2500/6 \times 0.6 \times 0.6)0.375$$
$$S_B = 5275 + 2600 = 7875 \text{ psi}$$
$$S_{TOT} = S_B + Q/A = 7875 + 2500/6 \times 0.6 = 8570 \text{ psi}$$

This is less than 100,000/8 = 12500 (satisfactory)

Step 3: Is the column stress below the critical buckling stress?

From equation (8):

$$2500/6 \times 0.6 \leq \pi^2 \times 4.5 \times 10^6 \times 0.6 \times 0.6/3 \times 24 \times 24$$
694 psi < 9240 psi (satisfactory)

Step 4: What thickness gives stiffness equal to steel spring?

From equation (7):

$$t = 0.125(6 \times 30/4.5)^{1/3}$$
$$t = 0.43 \text{ in.},$$

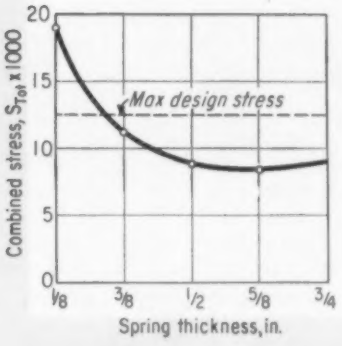
hence plastic spring slightly too stiff.

Step 5: Will $t = 0.47$ in. satisfy all stress conditions?

From equation (5) calculate S_B and S_{CR} on both sides of 0.43 in. Plot S_{TOT} for comparison.

t	S_B	Q/A	S_{TOT}	S_{CR}
0.250	17,158	1,670	18,828	1,665
0.375	9,960	1,110	11,070	3,600
0.500	8,143	833	8,976	6,400
0.600	7,875	695	8,570	9,240
0.625	7,900	666	8,566	10,000
1.000	9,727	416	10,143	25,650

Clearly, $t = 0.43$ in. gives $S_{TOT} <$ 12,500 psi and $Q/A < S_{CR}$. (satisfactory)



Step 6: Can a lower t be specified for economy?

From plot, $t = 0.375$ in. gives S_{TOT} well below max design stress; actual column stress is one-third critical buckling stress. If tests on 0.375-in.-thick spring show no serious disruption of harmonic operation, then specify thinner material to lower cost.

mate flexure strength for design should be 100,000 psi and flexure modulus 4.5 x 10^6 psi.

Plastic vs Steel Springs

The volume-efficiency entry in the table shows most dramatically the key advantage of reinforced plastics over steel for leaf springs: high energy-absorption capacity per unit volume. This unit of comparison is derived by dividing the energy capacity of a spring by its volume. For a cantilever beam—the form of most leaf springs—this volume efficiency is $0.11(S^2/2E)$, or about 10% the efficiency of the same beam used in tension. Compared with steel, however, the unidirectionally reinforced plastic leaf spring is over twice as efficient. This is because the theoretical usable strength S is nearly as high as that of steel, but modulus E is much lower—so the plastic can be deformed much further without permanent set. A practical result is that a multiple-leaf steel spring can often be replaced by a single plastic spring—eliminating packing and abrasion.

Glass-reinforced plastic springs have three other natural advantages over steel: they are much more resistant to corrosive media; essentially amorphous, they are not notch-sensitive, hence fatigue failure is a minor problem; because they dissipate energy faster, vibrations damp out quickly and smoothly—an important factor in conveyors and vibratory screens.

Design Procedure

As with other materials, designing leaf springs with these laminates rests on basic stress equations for the elastic configuration, which is usually a cantilever beam with both ends clamped. Equations for this leaf-spring structure are derived above; those for other configurations (e.g. a simple beam with fixed ends) can be derived similarly. Using the cantilever equations, design follows six steps:

(1) Compute the thickness that gives minimum bending stress.

(2) Using this value, compute the total combined stress in the beam (bending plus axial) and check it against max allowable design stress. Minimum safety factor = 4.

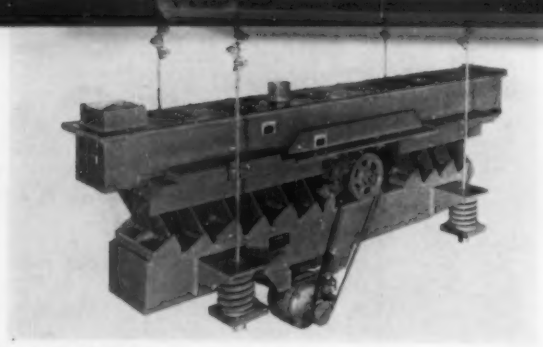
(3) Check the critical buckling stress for this thickness and see if it is exceeded by axial stress on the spring.

(4) Check the harmonic motion desired to see whether the computed thickness will provide adequate flexibility. In most cases, the problem is to replace a steel spring, thus equivalent stiffness becomes the criterion.

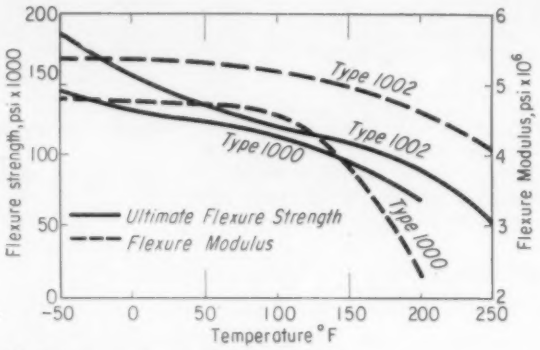
(5) Check the thickness required for equivalent stiffness (if it differs from that for minimum bending stress) to see if it will satisfy all stress conditions. Here, a plot of total stress in the beam is useful.

(6) Choose the final thickness considering the stress limitations, harmonic operation and added cost of unneeded plies.

Fastening the epoxy-glass leaf spring in place is by clamping between metal surfaces, so bolt holes through the spring are usually needed. These are drilled, rather than molded, using conventional glass-laminate cutting procedures—carbide-tipped bits, high speeds, slow feeds, and plenty of coolant. Clamping holes should not be placed closer to the spring edge than one hole diameter. In special cases, metal inserts are adhesive-bonded in place to provide better abrasion resistance in the clamping area.



20 leaf springs . . .
of directionally reinforced epoxy-glass laminate support the welded steel hopper on this natural-frequency conveyor unit. Springs are inclined to provide upward as well as forward motion to particles being conveyed.



High-temperature properties . . .
of two epoxy-glass spring materials. Type 1000 has a 35-minute cure, and 1-month shelf life; Type 1002 cures in 5 minutes, has a 6-month shelf life. For max properties, post-cure 16 hrs: at 225 F for 1000; 280 F for 1002.

High temperatures adversely affect the structural stability of all reinforced plastics, but epoxy-glass laminates are noted for retaining their mechanical properties. The property-temperature spectrums for two epoxy-glass combinations that have been widely used for springs are shown in the accompanying curves. Both are 65% glass–35% epoxy systems, but Type 1002 is structurally stable to 250 F, and Type 1000 cuts off at 200 F. Epoxies suitable for spring applications above 250 F are becoming available–in line with the rising use-temperature limits of all epoxies. For most spring design at high temperatures, properties are chosen from these curves.

For REPRINT of above article, just check P20 on one of the Reader Service cards bound in this issue.

EDITOR'S NOTE: Recent articles covering stress-analysis methods pertaining to reinforced-plastic leaf spring design include:

Glass-fiber Sleeve-springs for High Energy Absorption, Aug 17 '59, p 60—how to design a new kind of spring that can absorb almost five times the impact kinetic energy normally handled by equivalent steel springs.

Springs That Store Energy Best, Nov 10 '58, p 71—shows how well a spring absorbs energy depends on its shape and material; equations and tables compare many candidates.

DESIGN FEATURES IN NEW PRODUCTS

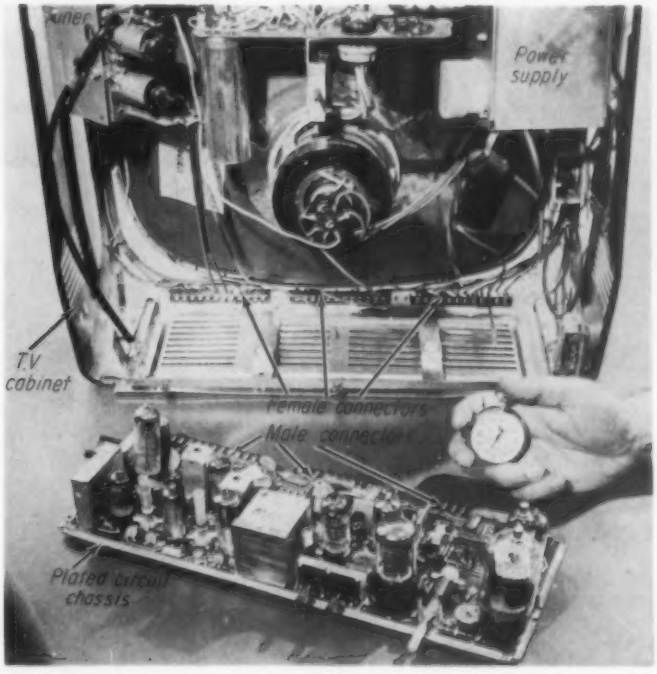
Sturdy TV Minimizes Maintenance Time

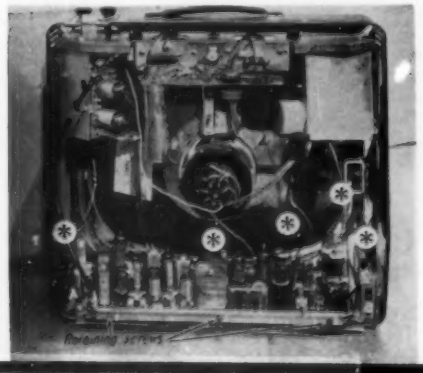
Plated circuits on a snap-out chassis (requires only 33 sec to remove) improve reliability and simplify service. Color coding of all circuits plus test-point labeling take guesswork out of troubleshooting.

Extensive testing rivaling that required for military equipment proved the theory behind the design concepts incorporated in this TV set. Chassis will be used in 1960-model, 17-in portable by Motorola Inc, Chicago.

Plated circuit . . .

is reinforced with fiberglass for improved impact and flexing strength. Spring-loaded levers and plug in connections support panel to withstand 11 g vibration during operation. Using four basic colors—red, green, yellow and blue—plus the natural color of copper leads, a total of 14 individual color-code combinations are provided. All plating is transferred to the opposite side with black coding to create a single-sided board from either side.



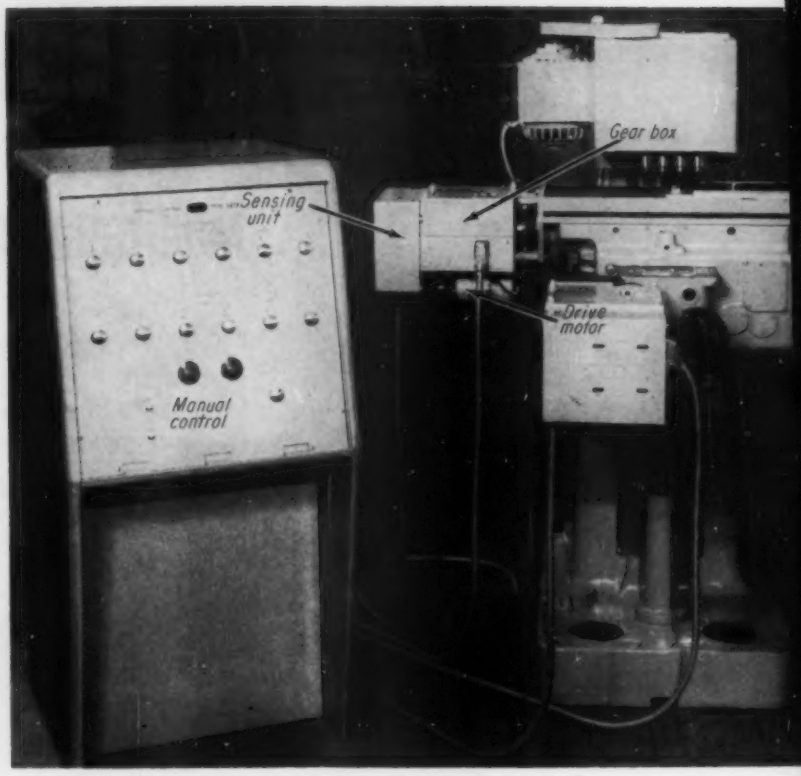


Chassis is removed . . .

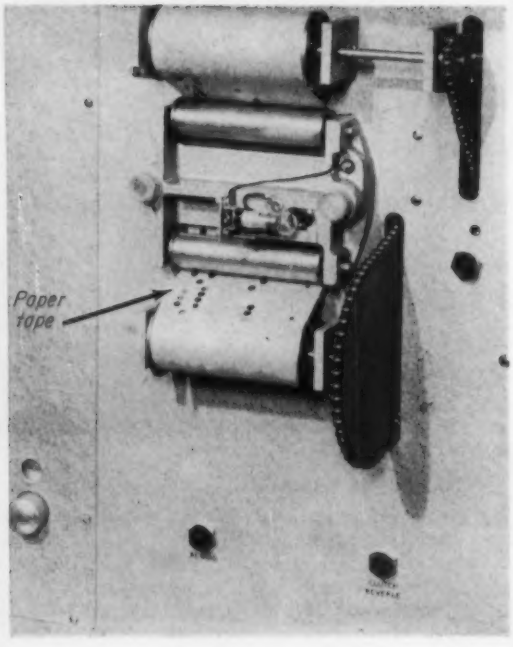
by loosening three retaining screws and disconnecting the five clip leads (marked with an asterisk—left). Spring-loaded levers on each side of plated circuit board are depressed to eject the complete chassis. Removal of the chassis can be accomplished in 33 seconds. All connections among chassis, power supply, and receiver are made by inserting edge of the board into three female connectors with 12 contacts each.

Simplified Tape Control Has No Electronics

Machine tool positioning system uses proven telephone relays and eliminates vacuum tubes to simplify circuits and maintenance. Oversize tape, 4 in. wide, permits use of large perforations which do not have to be precisely located for reading.



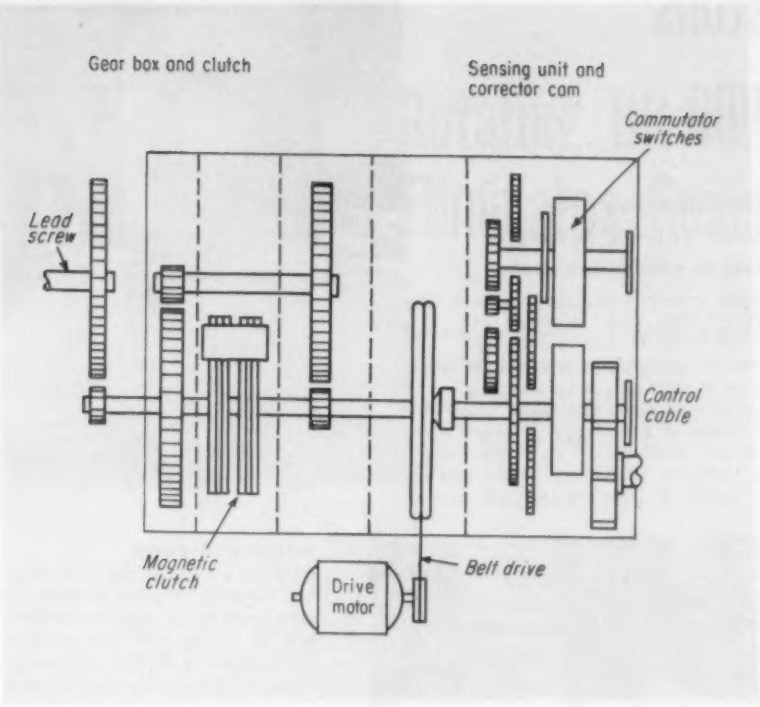
Coordinate setter controls two axes, up to 600 operations and a selection of 10 tools, with positive locking and unlocking. Control is by fully automatic single-hole pattern, decimal-code punched tape or manually, by dial. Control accuracy is better than one degree on the leadscrew. Autoset is produced by Airmec Ltd, High Wycombe, Buckinghamshire, Eng.



Wide tape . . .

developed for use with automatic control, has several advantages. Prepared on a typewriter-keyboard-style punch, the 4-in. tape width permits use of oversize holes which do not require precise locating for read-out. All information for a given position can be read instantaneously, eliminating the need for complex memory systems. Increased capacity of wide tape permits short tape length, to control 600 operations plus tool selection, locking and unlocking, stop signals and automatic tape rewind. Strong wear-resistant tape can be re-run thousands of times without replacement.

During tool operation the tape moves to the next information group. A signal from the machine indicates the operation is complete before the next operation begins. The machine operates unattended until the machining operation is finished. When the operations are completed, the control system trips an alarm and rewinds the tape automatically in preparation for the next component set-up.

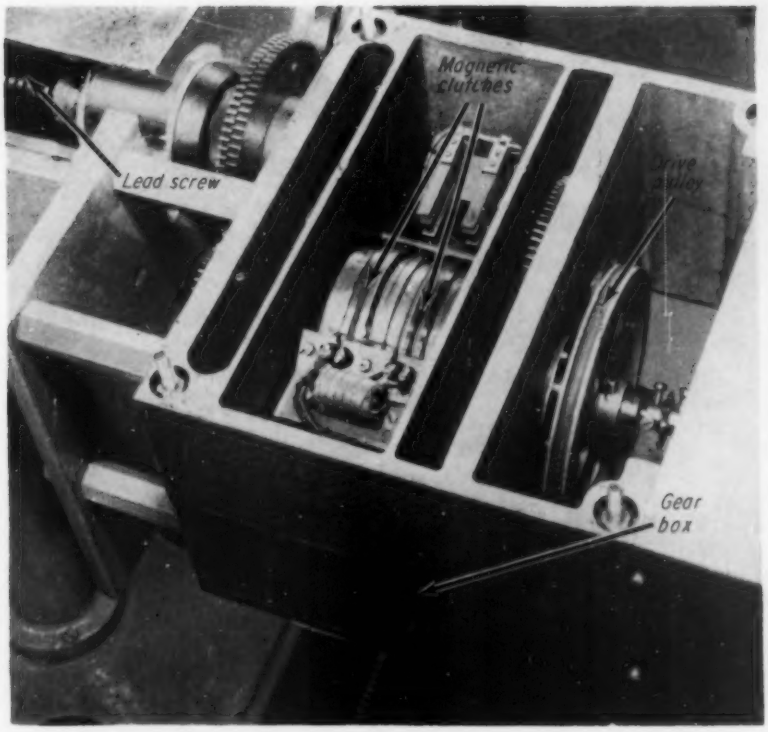


Control system . . .

either tape or manual, is based on total angular measurement taken from leadscrew. Full range in this unit is 36,000° or 100 leadscrew revolutions. Leadscrew is geared to four commutator disks. The highest-speed commutator disk turns one revolution for 3.6° of leadscrew revolution. The lowest-speed disk turns one revolution for the full leadscrew range—36,000°.

The perforated tape calls for a single commutator segment on each of the four disks. That segment is then electrically neutral. As the segment on the coarsest disk (1 rev = 36,000°) rides under its brush it stops signaling and the next coarsest disk takes over until its called-for segment reaches its brush. When the segment of the finest commutator disk (1 rev = 3.6°) reaches its brush the magnetic clutches open and the table is clamped. Motor speed is reduced during final approach stages to eliminate overshoot.

An adjustable cam in the sensing unit corrects for cumulative leadscrew errors. The leadscrew always drives in the same direction during final positioning to avoid backlash errors.



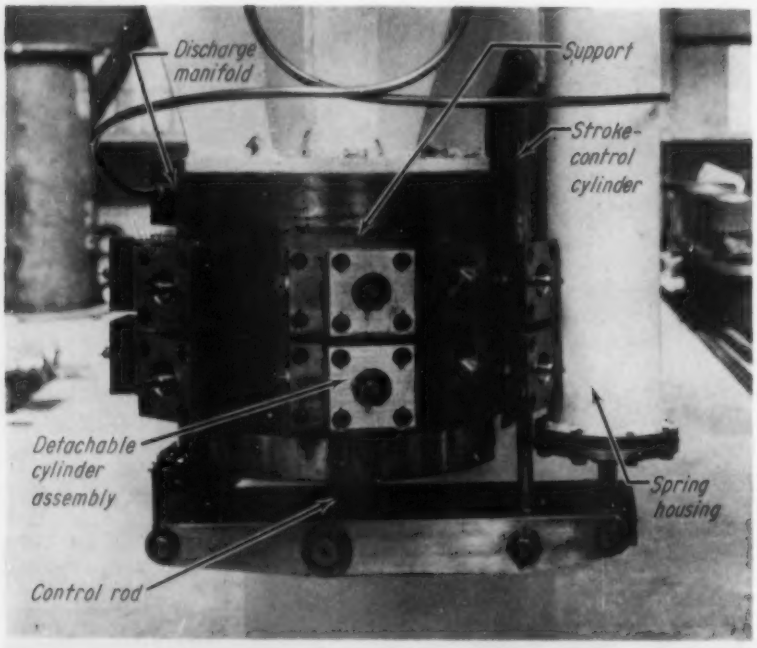
Gearbox and clutch . . .

are coupled directly to the leadscrew and the sensing unit is mounted on the rear face of their housing. The drive motor suspended beneath the gearbox drives the leadscrew through the clutches and gear reductions. A 2800 rpm drive motor with a 4.7 to 1 reduction in the belt drive provides a leadscrew velocity of 600 rpm or 1 in. per sec with a leadscrew pitch of 0.1 in. The velocity with the slow speed clutch engaged is 1/25 of maximum velocity or 24 rpm. The reversing motor has two speeds for speed reduction during final positioning. In conjunction with the gearbox, the motor can provide three possible speed changes as the final position is reached.

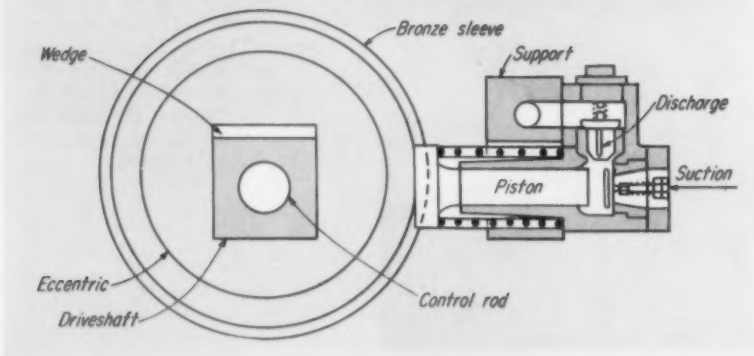
14 Identical Pistons in Simplified Pump

Individual cylinder-piston units ease construction and assembly of this efficient radial pump. Variable delivery is provided by moving eccentric centers to alter piston stroke.

Radial pump has 14 cylinders in two banks of seven each. Delivering 142 cu in./sec at 3000 psi, the submerged unit requires 62 hp and operates with volumetric efficiency of 98.3%. Control range for pump shown is 2800-3200 psi; by altering the control setting, delivery up to 6000 psi can be produced. The vertically mounted pump is suspended in its own supply tank, which also serves as base for the motor. Developed by Norman A. Graveson A. I. W., Stockton-on-Tees, England.



Submerged pump . . . requires no intake piping or manifolding. Discharge oil passes through passages bored in the supports and manifold to a 1-in.-high pressure line. Spring-loaded hydraulic cylinder operates the control rod by a connecting linkage suspended beneath the pump. The control rod is concentrically mounted in the square driveshaft and moves wedges between driveshaft and eccentrics to alter piston stroke.

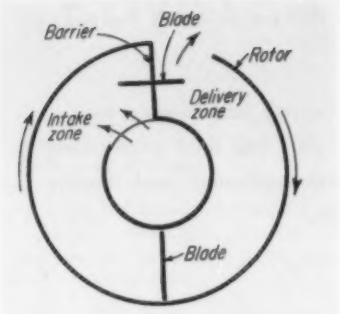


Cylinder units . . . are individual assemblies—each a spring-loaded piston with intake and discharge valves. The complete cylinder is bolted to the support during assembly and can be removed for maintenance. Bronze sleeves on the eccentrics bear on the piston-rod toes to compress the springs and complete the working stroke. Eccentrics are driven by a square shaft, stroke control is achieved by a movable wedge which shifts the eccentric centers to alter stroke length.

Rotating Blower Eliminates Seals

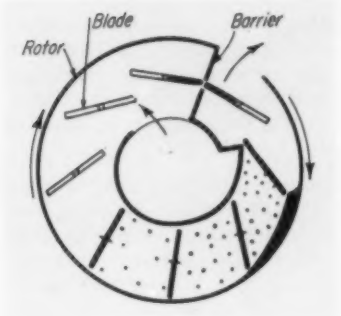
Low pressure blower delivers continuous stream of oil-free air for supercharging. Simplified parts minimize machining required and reduce production costs.

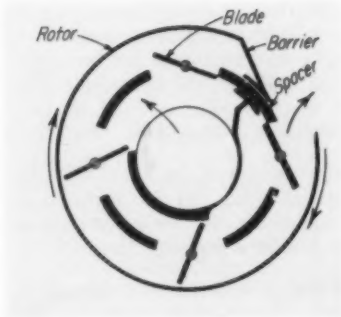
Producing 5 psig at 4500 rpm the blower delivers 200 cu ft of compressed air per min with an efficiency of 58.5%. Model shown is designed for 4-cycle engines but can be adapted to 2-cycle use or smaller units can be used for pumping liquids. The Bicera blade-type blower was developed by British Internal Combustion Engine Research Assn, Slough, Bucks, England.

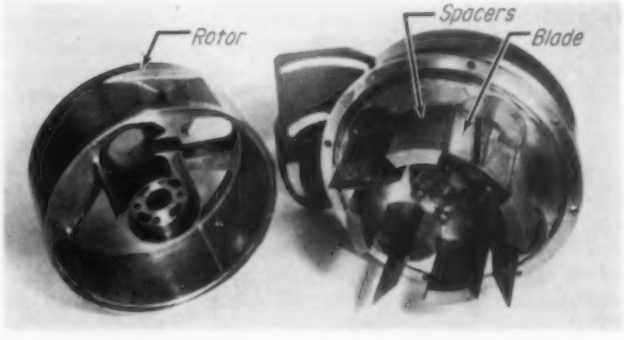


Development steps . . .
started with a simplified blower constructed to test the basic design. This consisted of a rotor formed into two cylinders with an annular channel. The channel was divided into intake and delivery zones by two blades which rotate about their fixed axes. A barrier in the channel is an integral part of the rotor and revolves with it. When positioned across the channel the blade acts as a seal and the rotating barrier acts as a piston. This produces an increase in volume in the intake zone and a decrease in the delivery zone which results in the continuous flow of air from the blower. Before the revolving barrier reaches it, the blade is turned 90° and passes through the narrow slot in the barrier.

A further modification incorporated eight blades and a modified annular shape to improve sealing during the final stages of compression. Rotation of each blade relative to the next results in variation of the space between blades and may be used to obtain internal compression. Intake air is trapped and then, by constricting the channel, the air is compressed before delivery.







Final form . . .
of blower was designed to lower production cost. Alternate blades are replaced by stationary spacers which seal off the slot in the barrier when it is between blades. Space between blades is so large that its volume does not change with blade tilt and compression takes place by backflow.

Rotating blades are mounted on shafts running through the back plate which also supports the spacers. A gear train, providing a 2 to 1 reduction, drives the blades and keeps them in phase with the rotor driven by the main shaft. This shaft transmits all the power required for compression. The rotor is covered by a delivery air casting which directs air from the rotating delivery zone to a flanged outlet.

8 *ways to* DESIGN ECONOMY INTO MALLEABLE IRON CASTINGS

The outstanding ductility of this metal invites post-forming to step in. It twists, rolls, straightens the part into final shape—keeping the casting process inexpensive and uncomplicated, and thereby cutting cost per part in mass production.

HERBERT L. KEE
Assistant Editor

When you design with malleable iron, overlooking its ductility is like throwing money away. In any fabrication method, the pennies saved on each part count up fast in mass production. With malleable iron, the savings can come from getting most out of ductility—it allows easy cold-forming after casting. This reforming makes several production shortcuts possible. For instance:

- Staking and crimping the cast metal does away with need for expensive fasteners.
- The castings can be accurately sized and straightened (this often contributes to favorable residual stresses that prolong service life).
- The casting process itself becomes cheaper because the cast shapes can be simpler—cold-forming the ductile metal will do the rest.

First, of course, the material must be chosen for its engineering properties. For most applications that require castings there is a choice of malleable irons. Minimum yield strengths of standard malleable irons run from 32,000 to 35,000 psi and about 55,000 psi ultimate, and in the pearlitic grades, from 45,000 to 100,000 psi yield and 65,000 to more than 120,000 psi ultimate. These materials have a standard fatigue strength about 50% of their ultimate strength and a notch fatigue strength of about 33%. The relatively high ductility (10 to 25% elongation in standard malleables) allows these materials to deform rather than fracture when the yield strength is exceeded. This is particularly helpful where slight deformations serve to distribute applied loads more evenly.

GUIDE TO ECONOMY

Second in importance to the successful functioning of a part is what it costs. Here the ductility of malleable iron—one of its outstanding properties, offers these main post-forming ways to save money and to attain better performance and life.

1 Sizing the casting by straightening and flattening makes closer tolerances possible. This step is becoming increasingly important where parts are machined by automatic machinery. Sizing brings the casting to the dimensions required for chucking and determines the basic locating points from unmachined surfaces. Helpful also is the excellent machinability of many of the malleable cast irons.

2 Coining helps obtain parallel surfaces. It can bring surfaces within ±0.010 in.—and within ±0.004 in. when the coining is done hot. The flattening by coining actually gives a better sliding surface than machined surfaces because the crests or local high points are flattened.

3 Holes can be punched while the casting is being trimmed and straightened. Square or other odd-shaped holes such as slots can be punched as simply as round ones. When made by cores such holes may add to cost because they may require additional finishing.

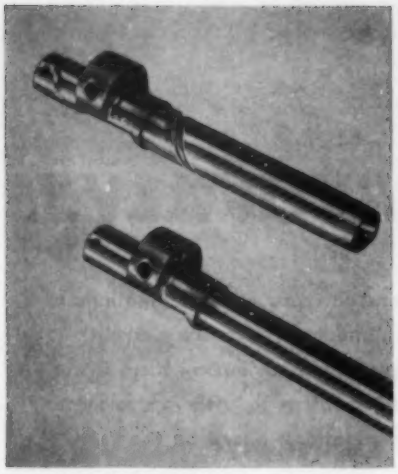
Diameter of punched holes should be greater than the thickness of the material punched and at least l-radius distance from the edge of the part.

4 Favorable residual stresses can be a valuable by-product. When straightening can be predicted so that residual stresses counteract the service stresses in the casting, the fatigue life of a part will increase.

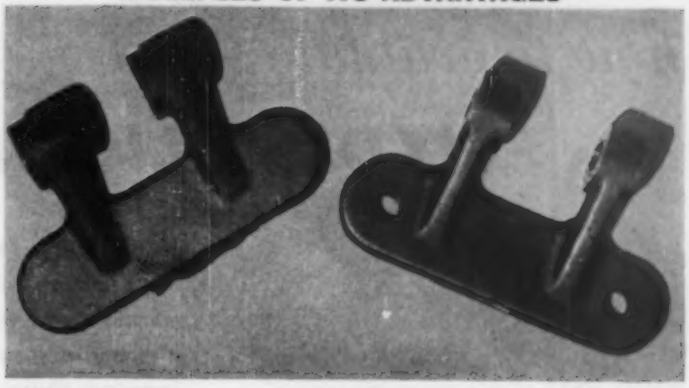
5 Stiffness, where needed, can be cast-in as ribs, webs, bosses, pads or beads. Here is where a single casting —one that incorporates this stiffness with flexibility— might compete with stampings. Some sheet-metal designs can only be reinforced by extra pieces—and therefore require the extra costs of assembly or fastening.

6 Handier shapes become possible for the casting process, especially in the thin sections. Although many of the shapes that can be post-formed can also be produced in the original casting, some shapes are had

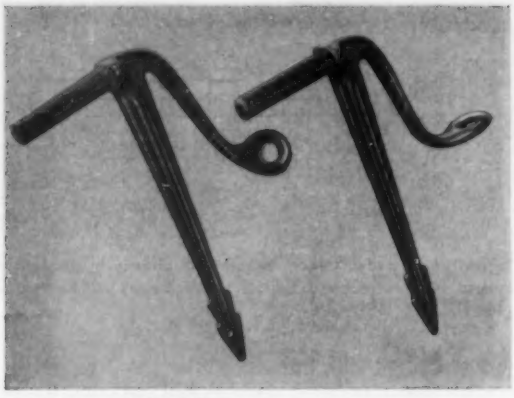
POST FORMING—
EXAMPLES OF ITS ADVANTAGES



Faster and cheaper . . .
than cutting—this helical groove for oiling was rolled into lawnmower-engine crankshaft at a rate of 600 pieces per hour. Similar economies can be had by rolling splines instead of cutting them.



Triple operation . . .
(before, left; after, right) trims the gate, punches the holes, and flattens the plate in this malleable hinge-casting.



Twisting and bending . . .
the loop of as-cast part (left) gives desired shape (right) without need for an extra core during casting; also keeps thin section in single plane for easier casting.

Square or round . . .
holes are punched—no need for coring, or disrupting smooth flow of metal during casting.

cheaper by forming or bending the part after it's cast. This eliminates need for bothersome cores and brings thin sections within a given plane, making the part easier to cast.

7 Assembly without fasteners becomes practical—by simple staking, bending or peening. A thin lip can be crimped or rolled over so it will enclose other parts; and cast studs, when peened over, become rivets. Housings can be spun over to envelop larger inserts. Parts so assembled can either be held rigidly or allowed to rotate within the first piece, depending on whether the fastener is loose or tight.

8 Splines, keyways, and oil grooves can be roll-formed. This gives the attendant benefits of a structure hardened by the cold-forming.

EDITOR'S NOTE: Other recent articles on materials and processes that guide design of castings:

Investment Castings . . . Tight Tolerances Can Be Even Tighter, July 20 '59, p 49. How to handle critical dimensions so castings can be used "as is" without need for finishing steps.

How to Choose—Investment Casting or Sintered Powder, June 8 '59, p 86. Although the processes seem competitive for many small mechanical parts, a closer look usually shows the choice is easy once you know what the part must do.

Forging Presses Strength Into Lightweight Castings, Feb 16 '59, p 61. Data on hybrid technique that improves cast parts by followup forging.

Cast-In Tubing, May 12 '58, p 76. Design tips to get low-cost parts that are pressure-tight, light-weight and compact.

Gray Iron Castings, Jan 20 '58, p 52. More data on high-temperature properties of this common material.

how to evaluate . . .

HYDRAULIC SERVOVALVES

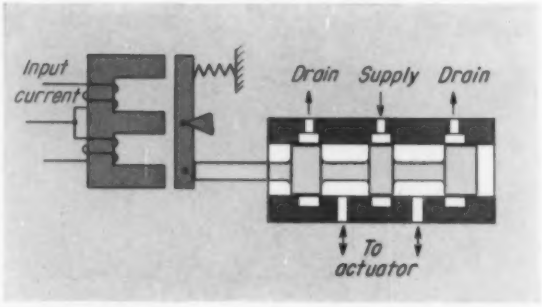
Today there are dozens of types and combinations of industrial servovalves, made by over two dozen manufacturers. However, choosing among them is not just a matter of comparing catalogs . . . there are these important design considerations, based on the valve characteristics.

WALTER ERNST, *vp and director of engineering*
The Commonwealth Engineering Co of Ohio
Dayton, Ohio

New demands for controlled hydraulic power have made the electrohydraulic servo—developed originally for aircraft—an important addition to the commercial market. Simple in concept, **a servovalve is a fluid valve that varies output flow or pressure in response to an input control signal.** The signal can be electrical, mechanical, fluid-pressure, force-reaction of a gyroscope, or even thermal-expansion of a trapped liquid. The most commonly chosen servovalve is electrohydraulic—the type discussed in this article. Its electrical input signal is easy to transmit and modify; and any other signal or response, including speed, acceleration, and light intensity, can be converted to a suitable electrical input.

In evaluating an industrial servovalve, **flow, pressure, accuracy** and **sensitivity** are usually the essential considerations.

Flow and pressure values are given in catalogs. But accuracy and sensitivity under actual operating conditions, even with complete catalog information, are difficult to predict—some knowledge of servovalve design is needed. Here are design tools that can make the evaluation simpler.



Single-stage servovalve controls oil flow directly in proportion to input current received by electric actuator, called torque motor.

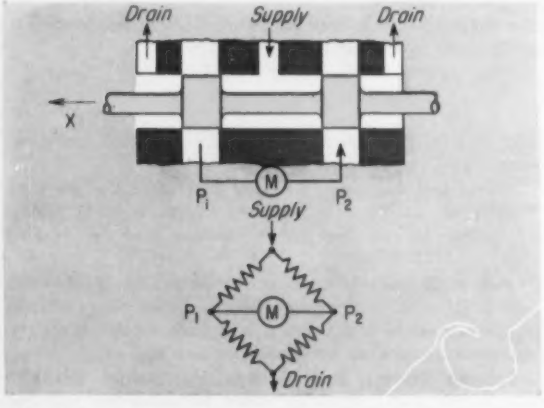


Fig 1 Hydraulic-electric analogy . . . between 4-way valve and Wheatstone bridge is key to accompanying method for calculating valve response. M is the hydraulic-motor load. Branches resemble electrical resistances, and fluid flow tends to obey Ohm's law.

VALVE DYNAMICS

What happens inside as well as outside a valve should be kept in mind when choosing servovalves for any system. These basics—circuitry, balance of forces on moving parts, output vs input, leakage—are important.

Wheatstone Bridge Analogy

Flow-pressure relationships inside a valve can be approximated by assuming that fluid resistance is akin to electrical resistance, then solving the resulting linear-resistance circuit by analogy.

The circuit in Fig 1—a 4-way valve—is from Transactions, ASME 75 (no. 6), 1953. One or more of the branches can have variable resistance to flow.

Oil flow, Q, cu in./sec, = about $100A\sqrt{\Delta P}$ for this or any valve. P is pressure in psi, and A is area of opening, sq in., for valve-spool position selected. The con-

stant, 100A, may be defined as "conductance" (an electrical analogy) because it is a measure of ability of valve to "conduct" fluid.

An ideal valve of type shown has no flow if spool is centered—conductance is zero. For any position away from center, conductance is zero on the closed side of bridge. Flow from open side goes through motor, then returns through diametrically opposite arm to drain. Conductances of opposite arms are equal, and equation for pressure drop through motor is:

$$P_M = P_S \times \frac{2Q_M^2}{(100A)^2}$$

Flow Forces on Spool

Most servo valves have spools for the main valve element, therefore the discussion will be based on spools. However, poppets, plates and other valve elements will have similar problems.

Actual flow through a spool valve is proportional to minimum cross-sectional flow area × √pressure drop. But flow causes side loadings and other disturbances that decrease accuracy and repeatability.

A perfect valve would be in perfect force balance for all flows, and a low-force input signal would be sufficient. Some spool designs come close to achieving this perfection, but special, costly contouring of the valve elements is needed. The following explains why.

Loadings on the valve during operation are both **hydrodynamic** and **hydrostatic.** When the loading is **hydrodynamic,** so-called "Bernoulli" forces are caused by the reaction of the jet of fluid escaping through the valve orifices. This jet—owing to the skew-symmetrical configuration of the orifice—is inclined to the valve axis at an angle of about 70°, Fig 2.

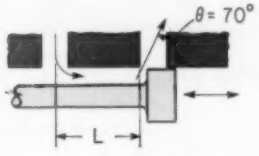


Fig 2

Two forces are generated. One, a "spring" force, F_T, lb, depends on total distance that spool moves. For an ideal valve (or an underlapped valve beyond the region of underlap):

$$F_T = -2Q \cos\theta \sqrt{\rho P_V}$$

where Q is total flow, cu in./sec, ρ is density, lb × sec²/in.⁴, and P_V is total pressure drop across valve (two orifices in series), psi. The negative sign indicates that this force, proportional to spool displacement, tends to center the valve. Combined with the equation for flow, Q = constant × $\sqrt{P_V}$ the final equation for F_T becomes

$$F_T = 0.47A\ P_V \quad \text{(for oil)}$$

In addition there is a velocity-responsive damping force having the magnitude

$$F_D = CwL \frac{dx}{dt} \sqrt{2\,\Delta P\rho}$$

where F_D is the force on one orifice only, and ΔP is the pressure drop across one orifice. L is the "damping length" or distance between centers of incoming and outgoing flows of the orifice. C is discharge coefficient, w is peripheral width of the valve opening, x is distance the valve moves . . . all in consistent units.

If L is positive, F_D will be positive and valve will be unstable, because of an increasing force in direction of valve travel. L will be positive when flow through the orifice is inward (toward the piston axis and vice versa). Since a conventional four-way valve has two orifices with damping lengths opposed in sign, an effective damping length is the algebraic sum of the two L's for the two chambers. If a valve has negative effective damping length, it will be stable.

The "Bernoulli forces" (preceding paragraphs) can be used for gain compensation of the second stage of a two-stage servo valve. The forces are proportional to the pressure drop across the valve and thus cancel the increase in gain that would otherwise take place.

Hydrostatic forces on a stationary valve can lock the spool—a well-known problem. Circumferential piston grooves can reduce such forces.

In theory, there is no lateral force (at right angles to axis) for any piston configuration having axial symmetry or for a decentered parallel piston. However, for a decentered conical piston, a cocked parallel piston, or one with burrs, lateral forces occur. The lateral force developed by a tapered piston will be:

$$F = \frac{\pi Lrb\ \Delta P}{2e}\left[1 - \frac{2c + b}{\sqrt{(2c + b)^2 - 4e^2}}\right]$$

where L = axial length of piston, in.; r = radius of piston, in.; b = radial taper, in./in.; ΔP = pressure drop across the piston, psi; e = eccentricity of piston, in., and c = radial clearance of large end of centered piston.

TYPICAL UNITS

Q	oil flow, cu in./sec
P	pressure, psi
P_S	supply pressure, psi
P_M	pressure drop in hydraulic motor, psi
P_V	pressure drop in valve, psi
A	flow area, sq. in.
F	force, lb
ρ	density, lb × sec²/in.⁴
L	damping length between orifices, in.
C	discharge coefficient
w	peripheral width of valve opening, in.
x	distance valve spool moves, in.
r	radius of piston, in.
b	taper, in./in.
e	eccentricity, in.
c	clearance, in.
u	underlap, in.
K_Q	flow gain, cu in./sec/in.
K_P	static stiffness, psi/in.
$K_{Q \text{ vs } P}$	slope of pressure-flow curve cu in./sec/psi

If the higher pressure is applied to the large end of the taper, the piston will be unstable and will be forced against the cylinder wall. Conversely, a tapered piston with the small end exposed to the higher pressure will tend to center itself . . . a stabilizing effect. However the small taper is difficult to make, and the piston is suitable for one-directional pressure application only. Non-tapered pistons with good dimensional accuracy, fine finish, and circumferential grooves are still the best answer for combatting undesirable hydrostatic forces.

Output vs Input

An important qualification for a servo valve is that large outputs be obtainable with small inputs. The ratio of output to input, called "gain," is usually measured with output in volume-flow units, and input in electrical current to the torque motor or other actuator. Input is also given as movement of pilot spool, in. There is a separate value of gain for each element of a servo—torque motor, first-stage amplifier, main spool—as well as for the overall valve.

Referring to the Wheatstone-bridge analogy, Fig 1, the over-all output-input relationship for an ideal 4-way valve can be readily analysed by partial differentiation:

- Flow gain

$$K_Q = \frac{\partial Q_M}{\partial x}, \quad \frac{\text{cu in.}}{\text{sec in.}}, \quad \text{for } P_M = \text{constant}$$

- Static stiffness (centered spool)

$$K_P = \frac{\partial P_M}{\partial x}, \quad \text{psi/in.}, \quad \text{for } x = 0$$

- Slope of pressure-flow curve

$$K_{Q\ vs\ P} = \frac{\partial Q_M}{\partial P_M}, \quad \frac{\text{cu in.}}{\text{sec psi}}, \quad \text{for } x = \text{constant}$$

For the general case, these final equations apply:

$$K_Q = 100w\sqrt{\tfrac{1}{2}(P_S - P_M)}$$
$$K_P = \text{infinity}$$
$$K_{Q\ vs\ P} = \frac{\text{conductance, cu in./sec/psi}}{4 \times \sqrt{\tfrac{1}{2}(P_S - P_M)}}$$

The oil supplied to an underlapped valve (the typical design) can be at either **constant pressure** or **constant flow.** Valve and load resistance determine flow in a constant-pressure valve.

Constant-pressure valve. All arms of the bridge are conducting; diametrically opposite conductances are equal. Denoting the underlap as u, then motor flow is:

$$Q_M = 100w(u + x)\sqrt{P_S - P_1} - 100w(u - x)\sqrt{P_1}$$

It follows that:

$$P_M = P_1 - P_2; \quad P_S = P_1 + P_2;$$
$$P_1 = \tfrac{1}{2}(P_S + P_M);$$
$$P_2 = \tfrac{1}{2}(P_S - P_M)$$

And:

$$Q_M = 100w(u + x)\sqrt{\tfrac{1}{2}(P_S - P_M)} - 100w(u - x)\sqrt{\tfrac{1}{2}(P_S + P_M)}$$

- Flow gain:

$$K_Q = 100w(u + 1)\sqrt{\tfrac{1}{2}(P_S - P_M)} - 100w(u - 1)\sqrt{\tfrac{1}{2}(P_S + P_M)}$$
$$\text{For } P_M = 0, \quad K_Q = 100w\sqrt{2P_S}$$

- Static Stiffness:

$$K_P = \frac{2P_S}{u}$$

- Slope of pressure-flow curve:

$$K_{Q\ vsP} = 100w\left[\frac{u + x}{2\sqrt{2(P_S - P_M)}} + \frac{u - x}{2\sqrt{2(P_S + P_M)}}\right]$$
$$\text{For } P_M = 0, \quad K_{Q\ vs\ P} = \frac{100wu}{\sqrt{2P_S}}$$

Constant flow valve. Motor pressure drop is:

$$P_M = P_1 - P_2$$
$$= \frac{Q_1^2}{[100w(u - x)]^2} - \frac{Q_1^2}{[100w(u + x)]^2}$$

It follows that:

$$Q_1 = \tfrac{1}{2}(Q_S + Q_M); \quad Q_2 = \tfrac{1}{2}(Q_S - Q_M)$$

And:

$$P_M = \frac{(Q_S - Q_M)^2}{4[100w(u - x)]^2} - \frac{(Q_S + Q_M)^2}{4[100w(u + x)^2]}$$

Flow gain can be obtained by differentiation of the implicit function, $F\ (x, Q_M)$:

$$\frac{\partial Q_M}{\partial x} = -\frac{\partial F/\partial x}{\partial F/\partial Q}$$

$$\frac{\partial Q_M}{\partial x} = \frac{(Q_S - Q_M)^2}{2Q_S(u - x)} + \frac{(Q_S + Q_M)^2}{2Q_S(u + x)}$$

- Flow gain:

$$K_Q = \frac{Q_S}{u}, \quad \text{for } P_M = 0, \quad Q_M = 0, \quad x = 0$$

Flow gain is now independent of P_M and a nonlinear function of valve displacement x; thus its characteristics are totally different from those of the constant-pressure valve.

- Static stiffness:

$$K_P = \frac{Q_S^2}{(100w)^2u^2}$$

- Slope of the pressure-flow curve can again be determined by differentiation of the implicit function, giving:

$$K_{Q\ vs\ P} = \frac{2(100w)^2(u - x)^2(u + x)^2}{(u + x)^2(Q_S - Q_M) + (u - x)^2(Q_S + Q_M)}$$
$$K_{Q\ vs\ P} = (100wu)^2 \div Q_S \quad \text{for} \quad x = 0, \quad Q_M = 0$$

A shunt is sometimes put across the load to improve stability. Such a shunt can be treated as a reduction of Q_M:

$$Q_{shunt} = Q_M - C_S\sqrt{P_M},$$
where C_S is conductance of shunt.

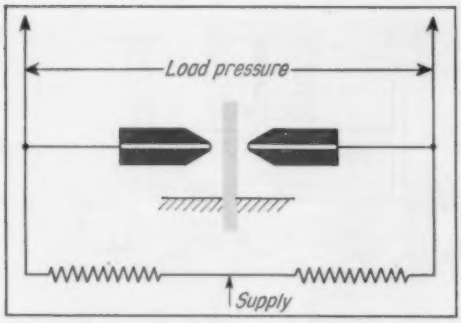


Fig 3 Flapper valve

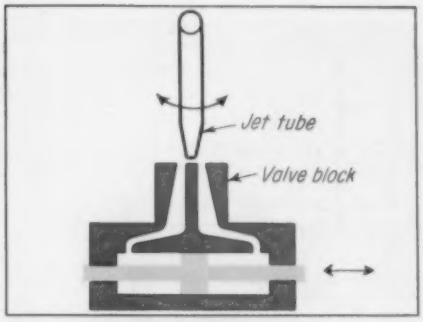


Fig 4 Askania nozzle

Leakage

In neutral position, leakage depends on spool underlap. Even with "zero" lap (± 0.000, 2 in.) some leakage exists and up to 5 percent of the rated horsepower may be dissipated. Hysteresis is the loop formed by the flow-vs-current curves for increasing and decreasing electrical current. Hysteresis of a good commercial valve should be below 2% of rated flow. "Zero shift" is a condition where zero flow does not occur at zero input current . . . a common condition for most servo valves. Therefore, some means for readjusting null should be provided.

VALVE STAGES

The simplest electrohydraulic servo valves have a single stage of amplification—the input signal drives the main spool directly. More common, however, are two-stage valves, which have these parts and functions:

Torque Motor Input

The electric actuator controlling a servo valve is often a "torque motor" whose thrust output is proportional to differential current supplied to it. The thrust is converted to spool or flapper position, controlled with restraining or centering springs, and the fluid output is proportional to differential current. A single-stage valve is directly actuated by the torque motor, while a two-stage valve uses the first stage–generally a nozzle or flapper–as a preamplifier. There has to be feedback between first and second stage, which can be done mechanically, with force or position feedback, or electrically with potentiometers. More often feedback is first-stage flow converted to differential pressure through a hydraulic Wheatstone-bridge arrangement, and applied to the spring-restrained second-stage spool valve.

The electrical input-power requirements for single-stage servos is high–1 to 6 watt–because the torque motor must drive the power spool. Two-stage servos can usually be controlled with less power. For example, simple flapper-nozzle 2-stage servos with no feedback operate on less than 0.1 watt. Three-stage designs also operate on less than 0.1 watt, but handle higher flows.

Differential currents of about 40 milliamps for single-stage and 15 milliamp for 2-stage valves are typical.

Preamplifiers

There is no preamplification in a single stage servo valve–the input force signal moves the main spool directly. But for better response, particularly for oil flows greater than about 4 gpm, more than a single stage is desirable. In a 2-stage servo, the input controls a smaller pilot valve, which in turn positions the main spool. For highest flows (100's of gpm), 3-stage servo valves–preamplifier, amplifier, and main valves–are also available.

The pilot (preamplifier) valve has many possible designs. It can be a spool, slide valve, flapper, nozzle-jet, or variations of each. Two common forms are the flapper valve and the Askania nozzle.

A **flapper valve**, Fig 3, has a continuous flow to tank from two opposing orifices. It is modulated by movement of the flapper between the orifices, thus forming a Wheatstone bridge with two fixed and two variable arms. The fixed orifices of the first stage are about 0.005 in. in diameter; the null clearance between nozzle and flapper is about 0.001 in.

The **Askania nozzle**, Fig 4, has a pivoted tube which discharges a jet of fluid. The kinetic energy of the jet is reconverted into pressure energy in the tapered passages, the amount depending upon the relative angular displacement of the jet from the respective passages.

Internal Feedback

The response–movement or pressure–of the main spool is sometimes fed directly back to the preamplifier inside the valve housing. In this way, the main spool motion can be stopped at the desired point by effectively neutralizing the output signal of the preamplifier. The feedback can be a mechanical linkage, a pressure signal, or a proportional spring bias of some sort.

TYPES OF VALVES

There are two main types of servo valves–**flow-control** and **pressure-control**. The **flow-control** type is used in systems the most. It provides an output flow proportional to input displacement at constant load pressure. It has a high impedance and is most suitable for noninductive (non-time-dependent) load. The **pressure-control** type, useful too, provides a pressure proportional to input displacement, has low impedance, is highly load-sensitive.

An "ideal" valve has high static stiffness in terms of psi/in. It will accelerate inertia loads quickly, resist disturbances and has low static error. Undesirable

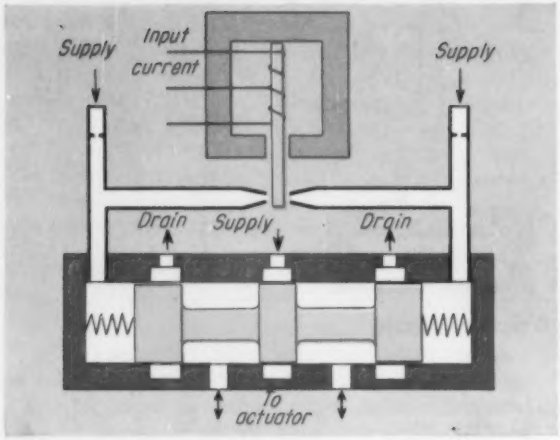


Fig 5 Flow-control type . . .
servovalve varies output flow in proportion to input electrical current. This example is 2-stage, with flapper preamplifier.

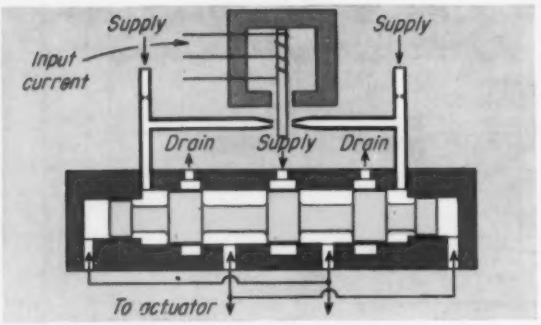


Fig 6 Pressure-control type . . .
servovalve varies output pressure in proportion to input electrical signal. Output pressure is fed to balancing piston at appropriate end of spool, giving feedback needed to control pressure.

valve characteristics are poor linearity and zero pressure-flow slope at neutral, which has a destabilizing effect.

A constant-pressure underlapped valve has a large flow gain, stable pressure-flow slope, and good linearity over most of the flow range. It has zero static error for inductive loads only. The error for resistance or static loads increases with static stiffness—some movement of the valve off neutral is required to produce the pressure that sustains a static load. This movement, Δx, = approx $(u/2)(P_u/P_s)$ for small ratios of P_u/P_s.

A **constant-flow underlapped valve** has poor linearity and is not suitable for precision servomechanisms; however, it works for less exacting jobs. An example is power steering for vehicles, where pump is practically unloaded when the valve is in neutral position. If pressure is from an accumulator or variable-displacement pump with pressure-compensating control, an ideal valve will minimize power consumption. In most cases a constant-displacement pump with relief valve is used, and it does not matter whether power is wasted through the underlaps of the valve or through the relief valve. An important point: choose pump to meet requirements of the servomechanism at maximum displacement rate or else the constant-pressure system will become a constant-displacement system. Maximum efficiency is obtained when $P_u = (2/3) \times P_s$.

Flapper-type valves, although often used as preamplifiers, are rarely used alone for high-power applications. As preamplifiers, they need a constant-pressure supply. For power applications, a slightly underlapped valve is a good compromise.

For any servo valve, dynamic response is very high. Some small valves can operate at frequencies as high as 900 cps—100 cps is common. A few have max capacities to 45 gpm, frequency response to 80 cps; one is able to pass 160 gpm, can respond to 30 cps. Time constants are normally from 2 to 5 millisec. A typical output-spool deadband is about 0.5% of rated output.

The well-known book by Walter Ernst, "Oil Hydraulic Power and Its Industrial Applications," is scheduled for a new printing—completely revised—in January.

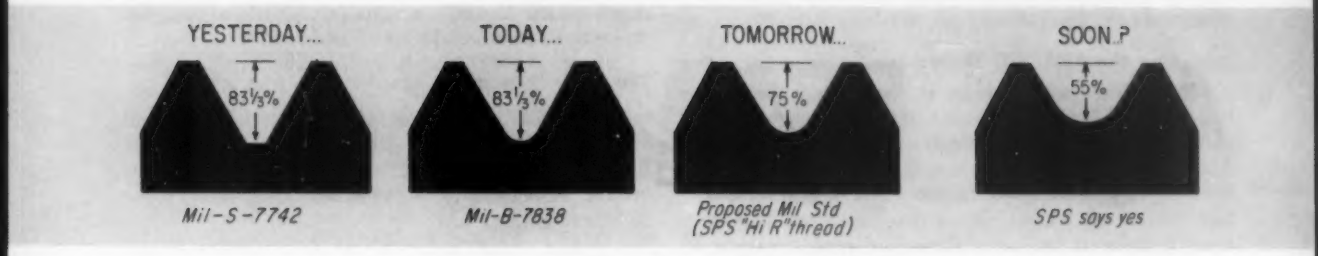
Some of the background information on servos for his book and for this article has been obtained from papers written for the ASME Transactions in 1952 and 1953 by J F Blackburn and S Y Lee; and from studies made by R E Bojar, B A Johnson, and Lee Schmid of the Cook Research Laboratories under Air Force Contract AF 33 (616)-2447. For this help, the author is grateful.

A pervious article by the author, "Fluid Transmission in High-pressure Systems," Oct '55, p 135, is an amplification of JIC (Joint Industry Conference) recommended standards for piping, tubing, flared and flareless fittings, pipe threads, and so forth—useful in the design of industrial hydraulic equipment.

EDITOR'S NOTE: A thorough introduction to servo valves appeared previously in these two articles:

New Techniques for Hydraulic Servo Design, Mid-Oct '55, p J11. Based on the simplest example—a single-stage servovalve—key equations are given for flow area of each port, travel of valve spool, and max flow. Response and stability are discussed in practical terms, introducing such terms as "gain" and "stiffness".

Hydraulic Control of Speed and Inertia, Sept '56, p 140. This detailed case-history compares two designs: a shaper-ram using a 4-way valve; and a planer-table with variable-delivery reversible pump.



the trend toward

BOLT THREADS WITH LARGE-RADIUS ROOTS . . .

Latest is a standard being set up for 75% threads—and on the test stands are bolts with shallower, 55% threads. All this is another example of a design advance, sparked by needs of the aircraft industry, that has broad applications.

ROBERT L SPROAT,
manager, research and development
Standard Pressed Steel, Jenkintown, Penna

Here are details of the new thread form that will shortly become a military standard. Recently introduced by SPS as its "Hi R" thread, the new form requires little change in design by a bolt manufacturer—the root of the thread is simply made with a larger radius, as shown above. But the benefits in terms of increased fatigue resistance are so pronounced that the government is moving rapidly to standardize the new thread form for the aircraft industry.

- **There is nothing proprietary about this large-radius root concept – other manufacturers, too, are making bolts with a 75%-depth rounded thread.**
- **Users of bolts will not have to make changes—standard taps can still be employed to tap threads into mating parts.**
- **Although the change is an outgrowth of the need for high-strength bolts in aircraft, there is no reason why the proposed thread form could not be put to work in all industries.**

Root Radius vs Fatigue

Tests have shown that threaded parts frequently fail much sooner than predicted by tensile-strength values alone. The cause, of course, is metal fatigue; or, to be more specific, the development of submicroscopic cracks in the metal under repeated application of a load —even a comparatively light load.

Fatigue can be triggered by high stress concentrations —such as are found at notches, changes of section, and other discontinuities. Hence the standard headed and threaded fastener, which is just about the most notch-filled structural part one can imagine, is also one of the most fatigue-prone parts made—especially when notch-sensitive, high strength alloys are employed in critical applications.

It is now possible to make the bolt head much stronger than the best thread. About 85% of properly made bolts and cap screws fail in the threads—and you can see why. Localized stresses at the thread roots were determined by SPS tests to be from 2 to 6 times the average stress in the unthreaded body. This can be noted from Table I, which gives stress-concentration factors for various root radii. There is a three-fold difference in stress buildup between the largest radius (0.010 in.) and the rather sharp one (0.001 in.).

Further fatigue testing on threaded fasteners at SPS isolated the three elements of good root design:

(CONTINUED, NEXT PAGE)

REPRINTED circle P19, inside back cover

• Root should be radiused–as large as possible.

• Radius should be continuous–a circular arc blending smoothly with flanks of the thread at point of tangency.

• Over-all root contour should be smooth throughout–free of any surface imperfections, worn-tool marks or other minor notches.

Rounding the 83 1/3% Thread

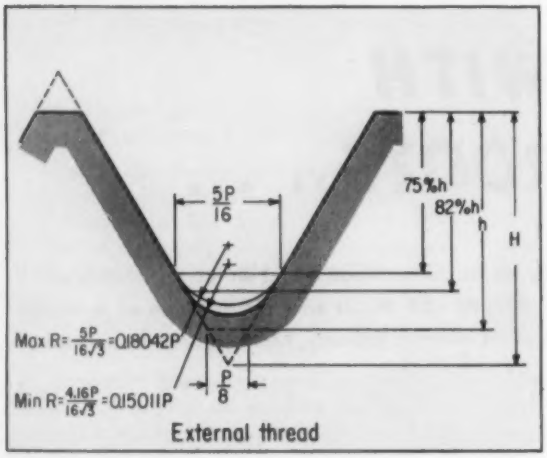
Some of this early work led to the military specification MIL-B-7838A–the present standard for threaded parts in aircraft–which, in effect, only radiused the root. Although this change was minor, it did cut down fatigue failures. Tension-tension fatigue tests showed that a bolt stressed to, say, 60,000 psi may take three or four times more stress cycles to failure than would an equivalent sharp-radiused bolt (1,000,000 vs 250,000 for the ¾ in. bolt on the curve).

Main reason why the 83⅓% depth was not dropped in favor of a large-radius thread was to avoid modifying the standard Go-ring gage for bolt threads. These gages must have a minimum thread depth of 83⅓% of full form. But it is a different story with respect to the internal-threads. A hole is seldom tapped with a thread depth greater than 75%. In fact, depth of the vast majority lie between 50 and 65%.

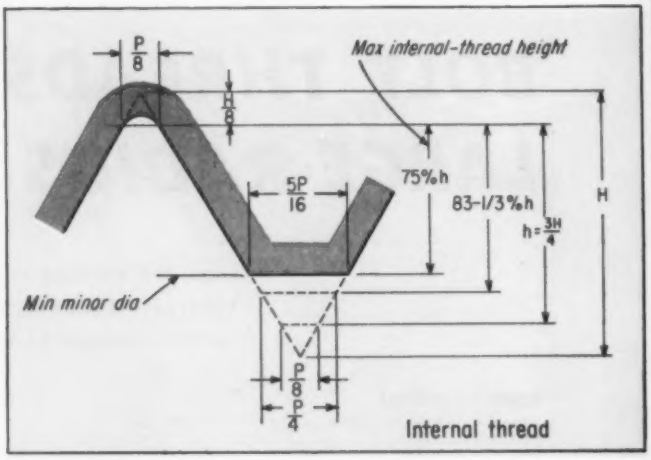
The 75% Thread

The recent demand for high-strength bolts brought forth fasteners which can take 220,000 psi in tension. But, as the tensile strength of bolts increased, the bolts became more sensitive to notches, hence more prone to fatigue failure.

A better thread root was obviously needed if still higher strength bolts were to be developed. Finally, the 75% thread was introduced by SPS as its "Hi R" thread, even though this meant that the minor thread dia in



Root of Hi R thread . . .
has radius that blends with thread flanks at a point 75% to 82% of Unified and American basic thread depth.



Internal thread . . .
to be mated with Hi R thread tap drill must be modified at the minor dia that max depth shall be 75% of basic thread height."

TABLE I—ROOT RADIUS vs STRESS

R = Root Radius, in. K = Stress Concentration Factor

R	0.001	0.002	0.003	0.004	0.005	0.006	0.007	0.008	0.009	0.010
K	6.0	4.8	3.9	3.4	3.1	2.8	2.7	2.5	2.3	2.2

TABLE II—CHANGES IN MINOR DIAMETERS OF GO-RING GAGES

THREAD		1/4-28	5/16-24	3/8-24	7/16-20	1/2-20	9/16-18	5/8-18	3/4-16	7/8-14	1-14	1 1/8-12	1 1/4-12	1 3/8-12	1 1/2-12
Standard Thread	Max.	0.2113	0.2674	0.3299	0.3834	0.4459	0.5024	0.5649	0.6823	0.7977	0.9227	1.0348	1.1598	1.2848	1.4098
	Min.	0.2108	0.2669	0.3294	0.3829	0.4454	0.5019	0.5644	0.6817	0.7971	0.9221	1.0342	1.1592	1.2842	1.4092
Hi R Thread	Max.	0.2152	0.2719	0.3344	0.3888	0.4513	0.5084	0.5709	0.6891	0.8054	0.9304	1.0438	1.1688	1.2938	1.4188
	Min.	0.2147	0.2714	0.3339	0.3883	0.4508	0.5079	0.5704	0.6886	0.8049	0.9299	1.0433	1.1683	1.2933	1.4183

ring gages must be opened up. (See Table II for the new root diameters.) These changes went over well with the aircraft industry and the government is now following up with a new standard to supplement MIL-B-7838.

Bolts with the new 75% thread not only have greater fatigue strength but their performance at elevated temperatures improved considerably (see stress-rupture curve above). Stress-rupture life of bolts in some cases increased as much as 100% at temperatures over 1000 F.

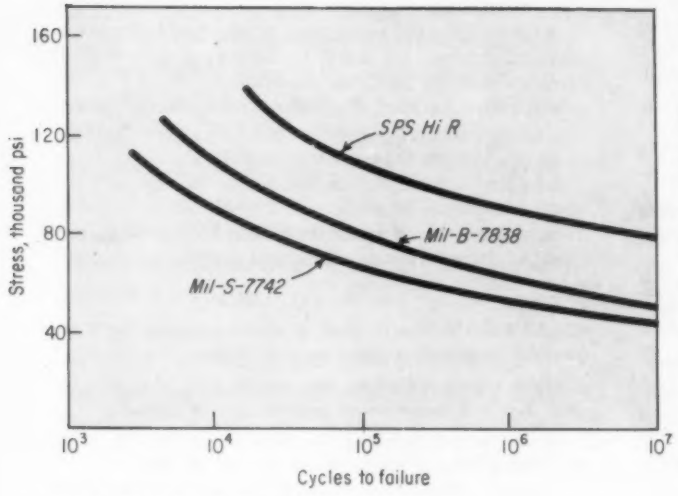
The 75% thread meets all present screw standards with but one minor change: The minor dia of existing gages must be ground down to the values listed in Table II. In use, the new thread mates with any female thread tapped to a maximum depth of 75%—which covers almost every standard nut or hole. Though the H-28 standard for tap drill sizes permits depths greater than 75% in some cases, in present production it's just not being done.

And a 55% Thread?

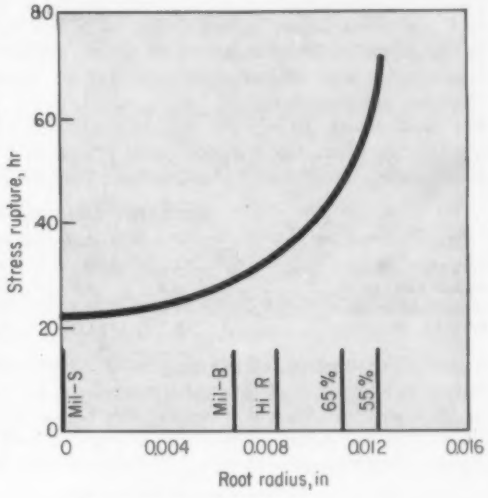
The question naturally comes up—why shouldn't thread roots be rounded still more—possibly to a 55% depth of the full thread. SPS is investigating the performance of bolts with a 55% thread and will publish complete test results in the near future. However, tests have already shown that these threads can double the number of hours that bolts will withstand a load at high temperatures when compared to the 75% thread (see stress-rupture curve).

Such a change must come about soon. It will mean scrapping or changing the gages—and special nuts and taps will be required. But this is a small price to pay for insuring the reliability of a bolted part in operation—whether the application be missile or lawnmower.

For REPRINT of above article, just check P19 on one of the Reader Service cards bound in this issue.



Tension-tension fatigue . . .
These tests were on ¾-in. bolt with differently radiused threads.



Stress-rupture tests . . .
on ½-in. bolts with differently radiused threads. The MIL-S-7742 thread is assumed to have zero radius—hence is plotted along the zero ordinate.

Ultimate tensile strength . . . ▶
at room temperature and at 1200 F.

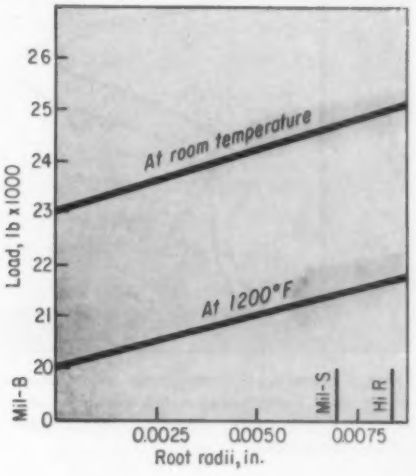


TABLE III—COMPARISON OF THREAD-ROOT RADII

THREAD		¼-28	⅜-24	½-20	¾-16	1-14	1½-12
MIL B	Max.	0.0051	0.0060	0.0072	0.0090	0.0103	0.0120
	Min.	0.0040	0.0050	0.0060	0.0070	0.0080	0.0090
Hi-R	Max.	0.0064	0.0075	0.0090	0.0113	0.0129	0.0150
	Min.	0.0054	0.0063	0.0075	0.0094	0.0107	0.0125

how the **SHADED-POLE MOTOR** *performs*

Our May 11 issue (p 198) described the "Unitized" concept of a motor manufactured by starting with a uniform airgap, then building stator and bearings around it. We asked for comparative performance data—new vs old way—and here is what the engineers responsible for the development said.

J E TRUBA
R N WEBBER
Specialty Motor Dept, G E Co, Fort Wayne, Ind

Smaller and more uniform airgap reduces electrical losses which, in turn, increase motor efficiency. Add to this: improved insulation, hydrodynamic bearings, and the low-efficiency shaded-pole motor takes on a new look. Efficiency gain is usable in several ways—smaller temperature rise offers higher power rating, or a smaller and lighter motor for the same power. If present performance is acceptable, then other characteristics can be improved. Here are some examples.

For same power rating, the following table compares old and new shaded-pole motors rated at 4 oz-ft torque at 1550 rpm—about 0.07 hp. All values are approximate.

	UNITIZED	CONVENTIONAL	
		today	10 yr ago
Efficiency, %	34	28	29
Motor dia, in	3.4	3.9	5
Stack length, in	1.5	1.3	1.3
Weight, lb	3.3	4.3	7.3

Accepting lowered efficiency permits more power–torque output up to 20% greater throughout the speed range is possible. Present weight and performance gives reduced electrical losses—by about ¼; and increased efficiency—23.48% vs 16.3% for a 2.25 lb motor rated at 0.8 oz-ft at 1300 rpm. Reduced heat losses might lessen the need for a cooling fan. In some motor-fan applications, the motor can now be on the suction side of the fan; fan output need not be directed against the motor for cooling.

Other efficiency improvements not directly related to airgap:

- Special resins, replacing paper-slot insulation in stator core, make stator an integral unit—insulated and bonded.
- Better dielectric properties, moisture protection, mechanical strength, are added to the over-all advantage of electrical redesign for better efficiency.
- Rigidly mounted hydrodynamic bearings permit capillary oil-retention system and 33% closer bearing-shaft relationship than previous motors.

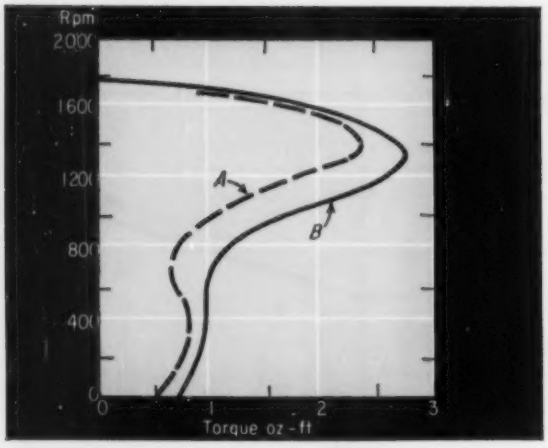
Like conventional shaded-pole motors, the new reduced-airgap design can be made with special built-in performance characteristics: multispeed, modified speed-torque, various voltages and frequencies, and all common controls, safety features and enclosures.

EDITOR'S NOTE: The problem of selecting motors has been carefully considered in these previous articles:

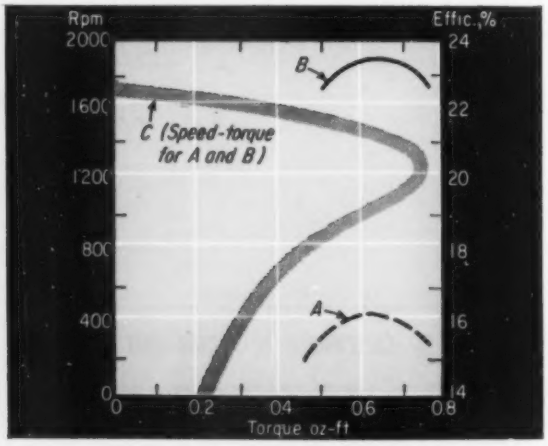
Which Fhp Motor for the Job, Jan 19, p 76, gives performance, cost and speed-control information on all motors.

Here's Help in Selecting the Right Motor, Oct 13, p 86, is a bibliography of several dozen previous PE articles.

Unitized and Conventional Motor Designed for . . .



Same Efficiency. Unitized motor (curve B) has higher useful torque than conventional motor (curve A) because new design techniques give better efficiency, permit higher magnetic flux without overheating.



Same Weight and Performance. With same weight, equivalent performance (curve C), efficiency of unitized motor (curve B) is greatly improved and motor can run at higher ambient temperatures and have longer life.

Tuition Supplements—

One Good Way To Help Our Colleges And Universities

The business community has made an impressive start in going to the desperately needed financial aid of our colleges and universities. Business contributions to higher education have increased from only $40 million in 1950 to $136 million in 1958.

This rise in financial aid to higher education should be a great source of satisfaction to the business community. But it goes only part way toward meeting the growing needs of colleges and universities for financial help. Over the next ten years business aid to our privately supported colleges and universities alone must increase to at least $500 million a year merely to provide decent faculty salaries and meet the increased operating costs of taking care of enrollments that will almost double.

One pervasive reason why many business firms have not joined the ranks of the companies contributing to higher education seems to be that, in the interest of prestige and public relations, they are making their provision of aid contingent upon finding some particularly novel way of providing it. So long as this point of view persists, business aid will lag, for there are simply not enough ways of providing financial aid that are both notably novel and sensible.*

How The Plan Works

There are, however, some well-tested ways of providing aid which improve rather than fade in appeal with more using. One such way is the making of supplemental tuition payments to colleges and universities at which a company's employees take courses.

Many companies have scholarship or tuition-refund programs which cover all or part of the costs to their *employees* of taking college courses. But, in most colleges and universities, tuition charges fall far short of covering the full cost of the education given. By making an unrestricted "cost-of-education" grant a part of their employee scholarship or tuition-refund plans, these companies could make a material contribution toward covering the *college's* full costs as well.

The tuition supplement can be a fixed amount or a percentage of the tuition charged. Some plans provide for supplements as high as 100% of tuition, though there is usually an upper limit to the total supplemental payment given for each employee enrolled in the institution.

The plan seems to have originated with the Ford Motor Company Fund. When we at McGraw-Hill first learned of it, it appealed to us as having so many advantages, and so few disadvantages, that we adopted it as one part of our own program of financial aid.

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*The efforts of the McGraw-Hill Publishing Company to find a suitable method of aiding higher education prompted the writing of a "more or less Socratic dialog" entitled *A Business Wrestling with the Problem of Aid to Colleges and Universities*. Copies of this pamphlet, which underlines the difficulty of finding both a novel and satisfactory method of providing aid, are available on request.

HOW THE HEADS OF SOME OF THE INSTITUTIONS TO WHICH McGRAW-HILL HAS MADE GRANTS FEEL ABOUT THE TUITION SUPPLEMENT PLAN

"We are pleased not only because this addition to the never adequate supply of non-earmarked funds is a most welcome one, but also because it attests to the fact that the employees of our neighboring business firms are benefiting from the courses we offer at times convenient for them. We hope this mutually beneficial plan may continue and grow with the years."

Grayson Kirk, President
Columbia University

"I shall take this occasion to express deep sentiments of appreciation, in my own name and in the name of the members of the Board of Trustees, for the very effective manner in which your corporation is aiding higher education by the payments made under your tuition supplement plan. Certainly your action is indicative of the fact that you realize industry and higher education must join forces to preserve the basic American system of free enterprise."

Very Reverend John A. Flynn, C.M.
President, St. John's University

"The growing recognition by business and industry of the financial needs and important services rendered to the community by the colleges and universities is most encouraging, and Temple University is deeply appreciative of the fine support extended through McGraw-Hill's program of supplementary grants."

Robert L. Johnson, President
Temple University

The Plan's Advantages

The main advantages of the tuition supplement plan are:

- **It is simple and easily administered.** Payments can be made when scholarships or tuition refunds are granted, or at another time convenient to the company.
- **It relieves the company of the difficult and sometimes disagreeable task of choosing one college rather than another.** The individual employee makes the choice.
- **It directly serves the interest of the company by encouraging and aiding the institutions where its employees take courses.** In a sense, the company makes contributions in direct proportion to the value it receives in education for its employees.
- **It directly serves the interest of the colleges and universities receiving the grants by getting money to them in the form most appreciated**—unrestricted funds to be used at the discretion of their administrators.

Largely because tuition supplements are unrestricted as to use, this plan enjoys the unqualified approval and gratitude of the schools receiving such aid. This is not true of some of the other plans for granting aid to colleges and universities.

Tuition supplements, of course, can't be regarded as large efforts relative to the need of higher education and the responsibilities of business. But they are a very practical and useful first step, involving almost no problems. If you are not familiar with the idea of supplemental grants, why not discuss it with some of your friends in the field of higher education?

The Price Of Novelty

Our experience with tuition supplements indicates that this is an excellent plan, and we are glad to recommend it to other companies looking for an effective method of providing financial aid to higher education.

At any rate, we hope that business firms will not postpone granting financial aid until they find some novel way of doing it. If they do, it will be another case of too little and too late.

This message is one of a series prepared by the McGraw-Hill Department of Economics to help increase public knowledge and understanding of important nation-wide developments. Permission is freely extended to newspapers, groups or individuals to quote or reprint all or parts of the text.

Donald C. McGraw
PRESIDENT
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PARKER-HANNIFIN FLUID-SYSTEM COMPONENTS

From HANNIFIN... unit construction to give you air valves that do more jobs

Hannifin ⅜" four-way valve with "universal" base and new Speed Control section. Single-solenoid actuated, 10 other actuators available.

Hannifin's exclusive "spool-poppet" seals bubble-tight at either end of its short stroke.

For complete I. I. C. compliance, valve is electrically inoperative until dust-tight, spin-mounted solenoid cover is replaced and fastened tightly. Result: no more clogged, jammed solenoids.

One of the versatile—and most popular—Hannifin air control valves is this "CC" series, single-solenoid model. It is available for either ¼" or ⅜" air lines and is gasket-mounted to its own base. This particular base (one of three choices offered) can either be O-ring gasketed to your manifold or mounted over an opening in your bracket or machine. It will receive all four lines from below or take the inlet line from below and the two cylinder lines out one side. Or, you can make all connections at the sides.

When it comes to actuation, Hannifin offers an even wider selection: hand, foot, cam, pressure, single or double solenoid.

When necessary, you can remove this entire valve from its base without disconnecting air lines. Or, the exclusive "spool-poppet" can be replaced without even breaking electrical connections.

The "CC" series, like all Hannifin valves, is designed with "full flow" internal passages as large or larger than its rated pipe size.

You will find these and most other Hannifin valves described in Hannifin's new "Valve Finder." Get your copy from your Hannifin man, listed in the A-Z volume of Thomas' Register, or write:

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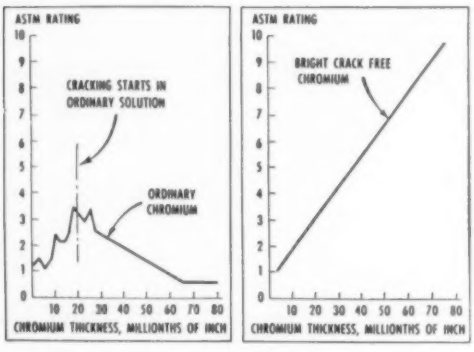
A DIVISION OF PARKER-HANNIFIN CORPORATION

Thicker chromium plate increases corrosion protection

Thicker chromium in general, and Unichrome SRHS® and Crack-Free deposits especially, are doing more to increase protection against corrosion than any other change in decorative chromium plating in the past 25 years. Latest research demonstrates this.

As far back as 1928, it was shown that ordinary chromium plate soon reaches a critical thickness. (See graph A.) At a thickness of approximately .020 mils, the chromium cracks microscopically. Through these openings, corrosives can reach the undercoatings, and ultimately attack the base metal, ruining the appearance and function of the plated part.



Graph A. Effect of increasing thickness of ordinary chromium on salt spray resistance . . . from Baker & Pinner data, SAE 1928. **Graph B.** Crack-Free Chromium ASTM corrosion ratings based on accelerated acetic acid salt spray tests.

Note, however, that before cracking commences, corrosion resistance *does* build up as the number of pores in the plate are reduced by the thicker deposit. Depending on undercoats, the effect of cracking can be modified.

DUCTILE CHROMIUM DOESN'T CRACK

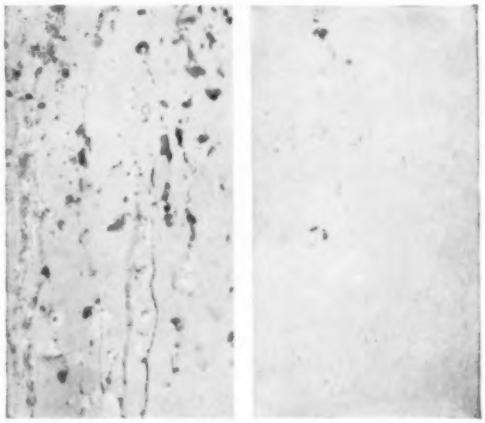
But see what happens in the case of Unichrome Bright Crack-Free Chromium. (Graph B.) An innovation in plating, it plates as thick as desired for practical purposes – entirely without cracks – and, as thickness increases, corrosion-admitting pores are eliminated. Protection keeps rising.

BETTER PROTECTION IN RECESSES

In the past, corrosion usually appeared in recessed areas of parts where little or no chromium could be plated to protect the base metal. This problem, too, is solved by Unichrome Bright Crack-Free Chromium which gives much better coverage and throwing power than previous processes.

LOW COST

The corrosion protection of decorative chromium can be improved several ways. Unichrome Crack-Free Chromium can be used alone; or in combination with other fast plating SRHS chromium processes to produce M&T "Duplex Chromium." This combination of chromium deposits, impossible from a practical standpoint for 25 years, is now done commercially with SRHS and Crack-Free Chromium, thereby eliminating need for new, larger tanks and saving thousands of equipment dollars.



Effect of thickness of CRACK-FREE Chronium over thin undercoatings (0.4 mil Nickel on steel) after 48 hours CASS test. Left—0.015 mil Chronium; right—0.045 mil Chronium.

Technical bulletins give more details on the benefits of thicker chromium plating with these specialized processes. Write for your copies to METAL & THERMIT CORPORATION, General Offices: Rahway, N.J.

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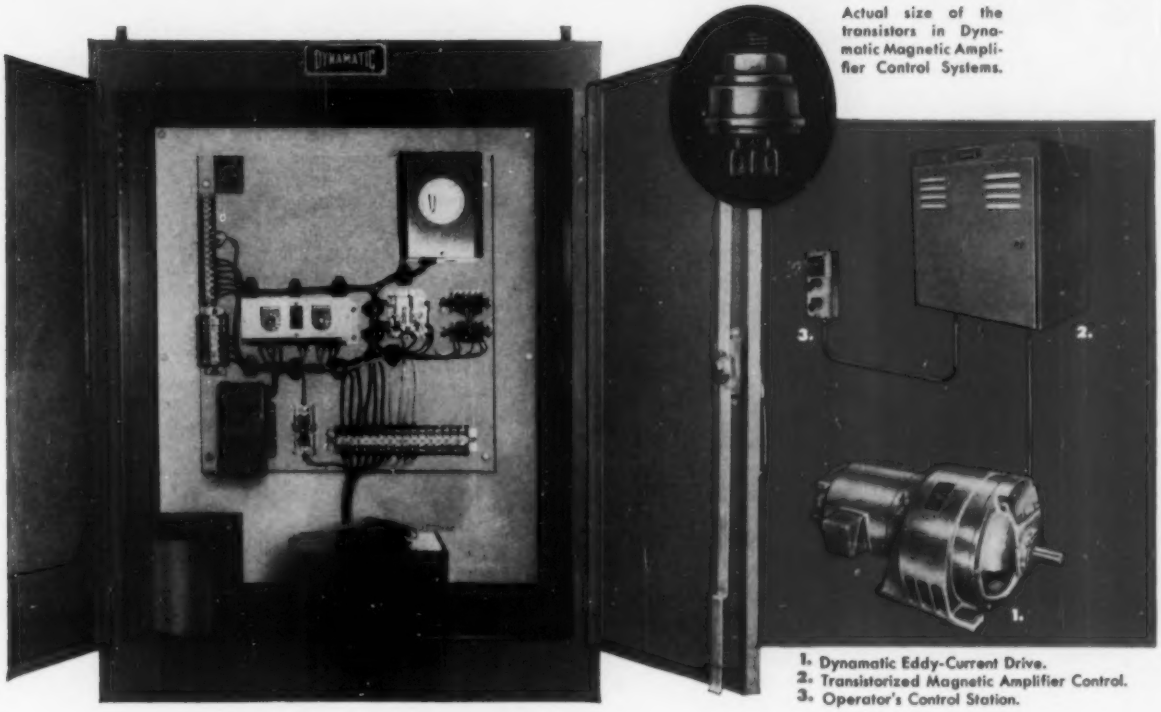

Actual size of the transistors in Dynamatic Magnetic Amplifier Control Systems.

1. Dynamatic Eddy-Current Drive.
2. Transistorized Magnetic Amplifier Control.
3. Operator's Control Station.

DYNAMATIC Transistorized Magnetic Amplifier Control Systems are based on a new principle using rugged electrical components designed to provide many times the life of components used in electronic speed control systems. Transistors, reactors, and silicon rectifiers take the place of vacuum tubes; there are no wearing parts to require maintenance, adjustment, or replacement. These transistorized controls are ideal for installation in remote areas and for unattended operation.

Used in combination with Dynamatic Eddy-Current Drives, Transistorized Magnetic Amplifier Controls provide infinite speed adjustment and accurate control for almost any application from five through 10,000 horsepower. Three essential components—drive, push-button station, and magnetic amplifier control—make up the Dynamatic Drive Package, which operates on alternating current. Standard control features include constant speed regulation, infinite speed adjustment, on-off clutch control, and jogging. Special features may be easily added to standard controls to meet the requirements of individual applications.

Dynamatic Transistorized Magnetic Amplifier Control Systems provide a high degree of accuracy and versatility—and are practically maintenance-free.

Send for New Illustrated Bulletin Describing Circuitry, Construction, and Operation.

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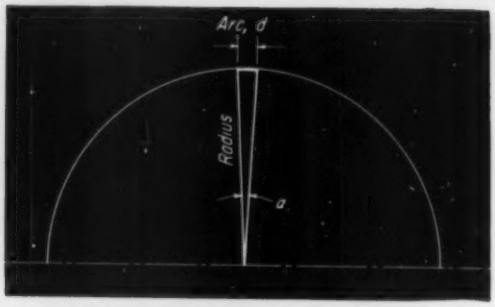


MARTIN A DONOHUE, *supt of gear mfg, Gleason Works, Rochester, NY*

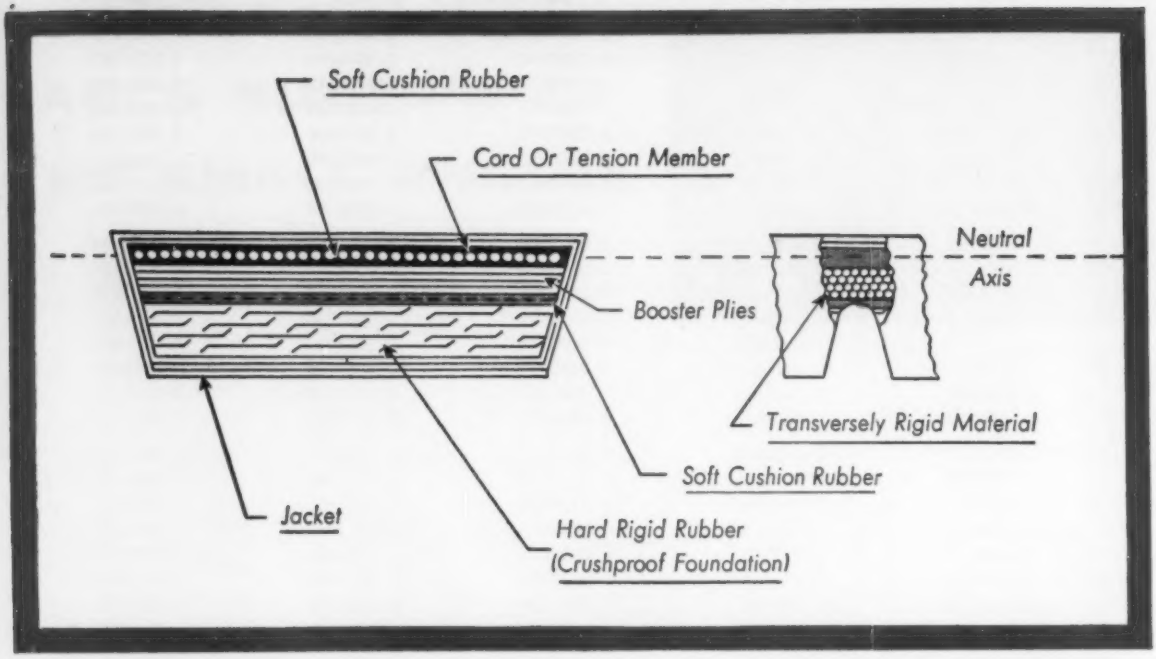
Radii	1 sec	2 sec	3 sec	4 sec	5 sec
0.125	0.0000006	0.0000012	0.0000018	0.0000024	0.0000030
0.250	0.0000012	0.0000024	0.0000036	0.0000048	0.0000060
0.375	0.0000018	0.0000036	0.0000054	0.0000072	0.0000090
0.500	0.0000024	0.0000048	0.0000072	0.0000096	0.0000121
0.625	0.0000030	0.0000060	0.0000090	0.0000121	0.0000151
0.750	0.0000036	0.0000072	0.0000109	0.0000145	0.0000181
0.875	0.0000042	0.0000084	0.0000127	0.0000169	0.0000212
1.000	0.0000048	0.0000097	0.0000145	0.0000193	0.0000242
1.125	0.0000054	0.0000109	0.0000163	0.0000218	0.0000272
1.250	0.0000060	0.0000121	0.0000181	0.0000242	0.0000303
1.375	0.0000066	0.0000133	0.0000199	0.0000266	0.0000333
1.500	0.0000072	0.0000145	0.0000218	0.0000290	0.0000363
1.625	0.0000078	0.0000157	0.0000236	0.0000315	0.0000393
1.750	0.0000084	0.0000169	0.0000254	0.0000339	0.0000424
1.875	0.0000090	0.0000181	0.0000272	0.0000363	0.0000454
2.000	0.0000097	0.0000194	0.0000290	0.0000387	0.0000484
2.125	0.0000103	0.0000206	0.0000308	0.0000412	0.0000515
2.250	0.0000109	0.0000218	0.0000327	0.0000436	0.0000545
2.375	0.0000115	0.0000230	0.0000345	0.0000460	0.0000575
2.500	0.0000121	0.0000242	0.0000363	0.0000484	0.0000606
2.625	0.0000127	0.0000254	0.0000381	0.0000508	0.0000636
2.750	0.0000133	0.0000266	0.0000399	0.0000533	0.0000666
2.875	0.0000139	0.0000278	0.0000418	0.0000557	0.0000696
3.000	0.0000145	0.0000291	0.0000436	0.0000581	0.0000727
3.125	0.0000151	0.0000303	0.0000454	0.0000605	0.0000757
3.250	0.0000157	0.0000315	0.0000472	0.0000630	0.0000787
3.375	0.0000163	0.0000327	0.0000490	0.0000654	0.0000818
3.500	0.0000169	0.0000339	0.0000508	0.0000678	0.0000848
3.625	0.0000175	0.0000351	0.0000527	0.0000702	0.0000878
3.750	0.0000181	0.0000363	0.0000545	0.0000727	0.0000909
3.875	0.0000187	0.0000375	0.0000563	0.0000751	0.0000939
4.000	0.0000194	0.0000388	0.0000581	0.0000775	0.0000969
4.125	0.0000200	0.0000400	0.0000599	0.0000799	0.0000999
4.250	0.0000206	0.0000412	0.0000617	0.0000824	0.0001030
4.375	0.0000212	0.0000424	0.0000636	0.0000848	0.0001060
4.500	0.0000218	0.0000436	0.0000654	0.0000872	0.0001090
4.625	0.0000224	0.0000448	0.0000672	0.0000896	0.0001121
4.750	0.0000230	0.0000460	0.0000690	0.0000921	0.0001151
4.875	0.0000236	0.0000472	0.0000708	0.0000945	0.0001181

Radii

	1 sec	2 sec	3 sec	4 sec	5 sec
5.000	0.0000242	0.0000485	0.0000727	0.0000969	0.0001212
5.125	0.0000248	0.0000497	0.0000745	0.0000993	0.0001242
5.250	0.0000254	0.0000509	0.0000763	0.0001017	0.0001272
5.375	0.0000260	0.0000521	0.0000781	0.0001042	0.0001302
5.500	0.0000266	0.0000533	0.0000799	0.0001066	0.0001333
5.625	0.0000272	0.0000545	0.0000817	0.0001090	0.0001363
5.750	0.0000278	0.0000557	0.0000836	0.0001114	0.0001393
5.875	0.0000284	0.0000569	0.0000854	0.0001139	0.0001424
6.000	0.0000291	0.0000582	0.0000872	0.0001163	0.0001454
6.125	0.0000297	0.0000594	0.0000890	0.0001187	0.0001484
6.250	0.0000303	0.0000606	0.0000908	0.0001211	0.0001515
6.375	0.0000309	0.0000618	0.0000926	0.0001236	0.0001545
6.500	0.0000315	0.0000630	0.0000945	0.0001260	0.0001575
6.625	0.0000321	0.0000642	0.0000963	0.0001284	0.0001605
6.750	0.0000327	0.0000654	0.0000981	0.0001308	0.0001636
6.875	0.0000333	0.0000666	0.0000999	0.0001333	0.0001666
7.000	0.0000339	0.0000679	0.0001017	0.0001357	0.0001696
7.125	0.0000345	0.0000691	0.0001035	0.0001381	0.0001727
7.250	0.0000351	0.0000703	0.0001054	0.0001405	0.0001757
7.375	0.0000357	0.0000715	0.0001072	0.0001430	0.0001787
7.500	0.0000363	0.0000727	0.0001090	0.0001454	0.0001818
7.625	0.0000369	0.0000739	0.0001108	0.0001478	0.0001848
7.750	0.0000375	0.0000751	0.0001126	0.0001502	0.0001878
7.875	0.0000381	0.0000763	0.0001145	0.0001526	0.0001908
8.000	0.0000388	0.0000776	0.0001163	0.0001551	0.0001939
8.125	0.0000394	0.0000788	0.0001181	0.0001575	0.0001969
8.250	0.0000400	0.0000800	0.0001199	0.0001599	0.0001999
8.375	0.0000406	0.0000812	0.0001217	0.0001623	0.0002030
8.500	0.0000412	0.0000824	0.0001235	0.0001648	0.0002060
8.625	0.0000418	0.0000836	0.0001254	0.0001672	0.0002090
8.750	0.0000424	0.0000848	0.0001272	0.0001696	0.0002121
8.875	0.0000430	0.0000860	0.0001290	0.0001720	0.0002151
9.000	0.0000436	0.0000873	0.0001308	0.0001745	0.0002181
9.125	0.0000442	0.0000885	0.0001326	0.0001769	0.0002211
9.250	0.0000448	0.0000897	0.0001344	0.0001793	0.0002242
9.375	0.0000454	0.0000909	0.0001363	0.0001817	0.0002272
9.500	0.0000460	0.0000921	0.0001381	0.0001842	0.0002302
9.625	0.0000466	0.0000933	0.0001399	0.0001866	0.0002333
9.750	0.0000472	0.0000945	0.0001417	0.0001890	0.0002363
9.875	0.0000478	0.0000957	0.0001435	0.0001914	0.0002393
10.000	0.0000485	0.0000970	0.0001454	0.0001939	0.0002424
10.125	0.0000491	0.0000982	0.0001472	0.0001963	0.0002454
10.250	0.0000497	0.0000994	0.0001490	0.0001987	0.0002484
10.375	0.0000503	0.0001006	0.0001508	0.0002011	0.0002514
10.500	0.0000509	0.0001018	0.0001526	0.0002035	0.0002545
10.625	0.0000515	0.0001030	0.0001544	0.0002060	0.0002575
10.750	0.0000521	0.0001042	0.0001563	0.0002084	0.0002605
10.875	0.0000527	0.0001054	0.0001581	0.0002108	0.0002636
11.000	0.0000533	0.0001067	0.0001599	0.0002132	0.0002666
11.125	0.0000539	0.0001079	0.0001617	0.0002157	0.0002696
11.250	0.0000545	0.0001091	0.0001635	0.0002181	0.0002727
11.375	0.0000551	0.0001103	0.0001653	0.0002205	0.0002757
11.500	0.0000557	0.0001115	0.0001672	0.0002229	0.0002787
11.625	0.0000563	0.0001127	0.0001690	0.0002254	0.0002817
11.750	0.0000569	0.0001139	0.0001708	0.0002278	0.0002848
11.875	0.0000575	0.0001151	0.0001726	0.0002302	0.0002878

(CONTINUED ON PAGE 101)

US RUBBER ROYAL VARIABLE SPEED BELT



HERE'S WHY THIS VARIABLE BELT IS NON-SQUASH, NON-SAG

No excuse for any more variable speed belt problems. The U. S. Royal Variable Speed Belt will lick any production problem – where other belts try and fail.

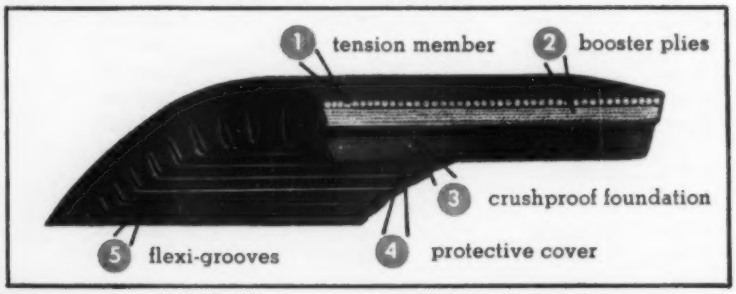
Note in the diagram the use of hard rigid rubber – the soft cushioning rubber in which cords or tension members are imbedded – the special jacket (oil and heat resistant).

The exclusive and complete crosswise rigidity in U. S. Royal prevents squashing. Lengthwise stretch is just about zero, by every test. *No sagging.*

U. S. Royal has complete accuracy regardless of speed changes – whether you switch from 2000 rpm to 10. It has scored a complete success in every textile mill, pulp and paper mill, chemical plant and metal working plant in which it has been installed.

• • •

Your nearest "U.S." Power Transmission Distributor will be glad to demonstrate the U. S. Royal on your own drives, at your own plant. You'll save a great deal in replacement costs and down goes downtime.



US RUBBER **Mechanical Goods Division**

United States Rubber

WORLD'S LARGEST MANUFACTURER OF INDUSTRIAL RUBBER PRODUCTS

Rockefeller Center, New York 20, N.Y. In Canada: Dominion Rubber Company, Ltd.

ARCS SUBTENDED BY SMALL ANGLES (CONTINUED)

Radii	1 sec	2 sec	3 sec	4 sec	5 sec
12.000	0.0000582	0.0001164	0.0001744	0.0002326	0.0002908
12.125	0.0000588	0.0001176	0.0001762	0.0002351	0.0002939
12.250	0.0000594	0.0001188	0.0001781	0.0002375	0.0002969
12.375	0.0000600	0.0001200	0.0001799	0.0002399	0.0002999
12.500	0.0000606	0.0001212	0.0001817	0.0002423	0.0003030
12.625	0.0000612	0.0001224	0.0001835	0.0002447	0.0003060
12.750	0.0000618	0.0001236	0.0001853	0.0002472	0.0003090
12.875	0.0000624	0.0001248	0.0001872	0.0002496	0.0003120
13.000	0.0000630	0.0001261	0.0001890	0.0002520	0.0003151
13.125	0.0000636	0.0001273	0.0001908	0.0002544	0.0003181
13.250	0.0000642	0.0001285	0.0001926	0.0002569	0.0003211
13.375	0.0000648	0.0001297	0.0001944	0.0002593	0.0003242
13.500	0.0000654	0.0001309	0.0001962	0.0002617	0.0003272
13.625	0.0000660	0.0001321	0.0001981	0.0002641	0.0003302
13.750	0.0000666	0.0001333	0.0001999	0.0002666	0.0003333
13.875	0.0000672	0.0001345	0.0002017	0.0002690	0.0003363
14.000	0.0000679	0.0001358	0.0002035	0.0002714	0.0003393
14.125	0.0000685	0.0001370	0.0002053	0.0002738	0.0003423
14.250	0.0000691	0.0001382	0.0002071	0.0002763	0.0003454
14.375	0.0000697	0.0001394	0.0002090	0.0002787	0.0003484
14.500	0.0000703	0.0001406	0.0002108	0.0002811	0.0003514
14.625	0.0000709	0.0001418	0.0002126	0.0002835	0.0003545
14.750	0.0000715	0.0001430	0.0002144	0.0002860	0.0003575
14.875	0.0000721	0.0001442	0.0002162	0.0002884	0.0003605
15.000	0.0000727	0.0001455	0.0002181	0.0002908	0.0003636
15.125	0.0000733	0.0001467	0.0002199	0.0002932	0.0003666
15.250	0.0000739	0.0001479	0.0002217	0.0002956	0.0003696
15.375	0.0000745	0.0001491	0.0002235	0.0002981	0.0003726
15.500	0.0000751	0.0001503	0.0002253	0.0003005	0.0003757
15.625	0.0000757	0.0001515	0.0002271	0.0003029	0.0003787
15.750	0.0000763	0.0001527	0.0002290	0.0003053	0.0003817
15.875	0.0000769	0.0001539	0.0002308	0.0003078	0.0003848
16.000	0.0000776	0.0001552	0.0002326	0.0003102	0.0003878
16.125	0.0000782	0.0001564	0.0002344	0.0003126	0.0003908
16.250	0.0000788	0.0001576	0.0002362	0.0003150	0.0003939
16.375	0.0000794	0.0001588	0.0002380	0.0003175	0.0003969
16.500	0.0000800	0.0001600	0.0002399	0.0003199	0.0003999

Corrected table for BEVEL GEAR CALCULATIONS, page 93, Sep 14, 1959. Item 46 on page 95 should also be Changed from $(44)^3$ to $(43)^3$.

Gear Addendum for 1 D.P. Ratio = (No. of gear teeth)/(No. of pinion teeth)

Ratios		Addendum, in.	Ratios		Addendum, in.	Ratios		Addendum, in.	Ratios		Addendum, in.
From	To		From	To		From	To		From	To	
1.00	1.01	1.000	1.15	1.17	0.880	1.42	1.45	0.760	2.06	2.16	0.640
1.01	1.02	0.990	1.17	1.19	0.870	1.45	1.48	0.750	2.16	2.27	0.630
1.02	1.03	0.980	1.19	1.21	0.860	1.48	1.52	0.740	2.27	2.41	0.620
1.03	1.04	0.970	1.21	1.23	0.850	1.52	1.56	0.730	2.41	2.58	0.610
1.04	1.05	0.960	1.23	1.25	0.840	1.56	1.60	0.720	2.58	2.78	0.600
1.05	1.06	0.950	1.25	1.27	0.830	1.60	1.65	0.710	2.78	3.05	0.590
1.06	1.08	0.940	1.27	1.29	0.820	1.65	1.70	0.700	3.05	3.41	0.580
1.08	1.09	0.930	1.29	1.31	0.810	1.70	1.76	0.690	3.41	3.94	0.570
1.09	1.11	0.920	1.31	1.33	0.800	1.76	1.82	0.680	3.94	4.82	0.560
1.11	1.12	0.910	1.33	1.36	0.790	1.82	1.89	0.670	4.82	6.81	0.550
1.12	1.14	0.900	1.36	1.39	0.780	1.89	1.97	0.660	6.81	∞	0.540
1.14	1.15	0.890	1.39	1.42	0.770	1.97	2.06	0.650			

THEY LOOK ALIKE...
Sparton horn coil of aluminum strip
BUT THERE'S AN IMPORTANT DIFFERENCE INSIDE!
Old type magnet wire coil

Sparton Automotive switches to Reynolds Aluminum strip conductor . . . eliminates 11 parts, lowers costs, improves design, simplifies production.

One of the biggest advances in automotive horn coil design was accomplished this year when Sparton Automotive switched from magnet wire coils to Reynolds Aluminum Strip Conductor. Sparton will be using millions of these coils for 1960 automobiles.

The decision to change to aluminum strip conductor came after many months of testing and research in collaboration with Reynolds engineers and laboratories. The reason for the changes were many . . .

Lower Costs . . . in terms of equal conductivity aluminum is lower in cost than other conductors . . . eleven parts were eliminated reducing the cost of the overall unit . . . interleaving material used with strip conductor is more economical than magnet wire insulation.

Improved Performance . . . higher dielectric strength because of interleaving material . . . turn-to-turn voltage breakdown is reduced . . . space factor is much higher than round magnet wire . . . arrangement of magnetic lines of flux is more uniform . . . heat dissipation is improved . . . less hot spots.

Simplified Production . . . no bobbin flanges or winding spools needed . . . impregnating and baking coil not necessary as with wire coil . . . indefinite choice of conductor area (by width and gauge) as opposed to copper wire. . . insulation stresses created in winding do not occur in strip winding.

Sparton Automotive realized all of these advantages . . . you may too by considering Reynolds Aluminum Strip Conductor in electro-magnetic applications.

Reynolds Aluminum Strip Conductor is available in two forms, interleaved or anodized. The interleaved form is furnished by Reynolds in coil form and can be wound with the customers choice of interleaving material. Anodized strip conductor is customarily used in the heavier gauges in transformers, magnetic clutches, and brakes. Whatever the choice you can depend on Reynolds, the acknowledged pioneer in the development of strip conductor. Our engineers have worked on hundreds of these applications. For more information contact the nearest Reynolds Sales Office or write *Reynolds Metals Company, Box 2346-HN, Richmond 18, Virginia.*

Write to address above for brochures on Reynolds Aluminum and anodized and interleaved strip conductor.

Watch Reynolds TV shows—"ALL-STAR GOLF" and "ADVENTURES IN PARADISE"—ABC-TV.

REYNOLDS ALUMINUM

. . . MICROMETER SETTING

For Exacting Flow Control

HANNA *Flo-Set*® VALVES

Hydraulic pressure to 1000 psi
Sizes ¼", ⅜", ½", ¾"
Temperatures to 250°F

Air, Oil, water operation to 250 psi
Sizes ¼", ⅜", ½", ¾"
Temperatures to 250°F

OTHER HANNA VALVES
include solenoid, pilot, hand and foot operated types

FOR AIR • OIL • WATER • OTHER FLUIDS

REGULATING cylinder speeds or controlling fluid flow of air, oil or water is so simple with Hanna Flo-Set Valves . . . you need only turn the valve body one revolution to adjust from zero to full pipe capacity. Micrometer-type graduations are numbered to indicate the percentage of pipe capacity. Once set, the position can be locked to avoid accidental change. Future resetting to a predetermined flow requires no guesswork.

Hanna Flo-Set Valves allow full flow in one direction—controlled flow in the opposite. Used in pairs, they regulate independently cylinder instroke and outstroke speeds. Hanna Flo-Set Valves assure uniform speed, smoother action and improved performance of cushioned and non-cushioned cylinders.

Valve sizes are ¼", ⅜", ½", and ¾" . . . a ¼" Jr. model, without graduations or locking collar, is available for light piping and tubing.

Whatever your problem of precision fluid control may be—you will find the best answer in Hanna Flo-Set Valves—designed, built and guaranteed by Hanna's 50 years of experience in hydraulics and pneumatics.

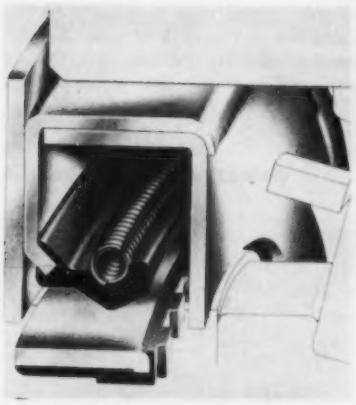
WRITE FOR LITERATURE AND COMPLETE DETAILS,
or consult your classified telephone directory or Thomas' Register for your nearest Hanna representative.

Hanna Engineering Works

HYDRAULIC AND PNEUMATIC EQUIPMENT . . . CYLINDERS . . . VALVES

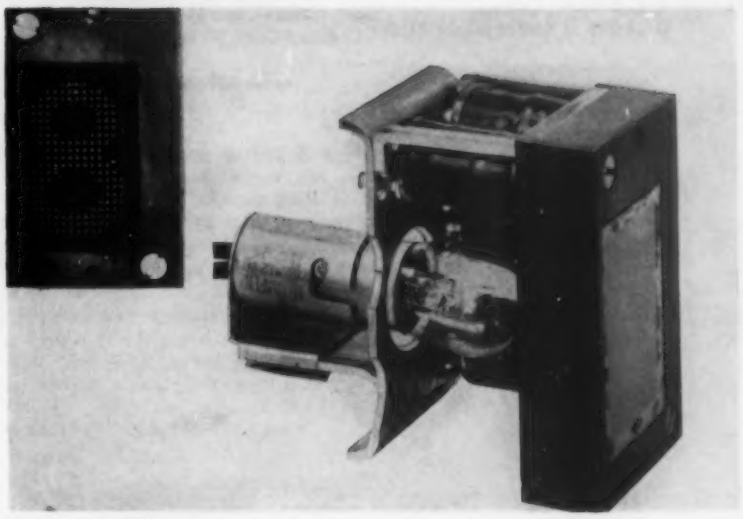
1763 Elston Avenue • Chicago 22, Illinois

SIGNIFICANT COMPONENTS MATERIALS PROCESSES



Oil seal has wear sleeve . . . with an inside surface of rubber and outside of polished metal. Sleeve turns with shaft on which it is mounted, which means that sealing lip runs on sleeve rather than shaft. This is said to reduce shaft wear and avoid difficulties caused by certain types of shaft surface conditions. Seal is spring-loaded and is available, at present, in shaft sizes of 1¼-in. and up, for both single and double-lip applications. Delivery after the first of the year. **National Seal Div, Federal-Mogul-Bower Bearings Inc, Redwood City, Calif.**

Circle 300 on Reader Service Card



Data readout . . . electromechanically converts voltage signals into numbers or various types of symbols or characters. Slides perforated according to certain patterns are moved relative to each other by four electro magnets, to produce in each readout unit as many as 16 numbers or symbols, one at a time. Characters are projected when proper holes in slides line up, permitting light to pass through them. Readout units measure 2½ x 1¼ x 2⅝ in. long. Require 12 v, 150 milliamp per binary level. Priced at $68. Deliveries are scheduled to begin late December '59. **Genesys Corp, 10131 National Blvd, Los Angeles.**

Circle 302 on Reader Service Card

Quick-change lubricator . . . releases bowl upon touching lock-release button. Button also automatically bleeds air from bowl before unlocking occurs. Available in ¼, ⅜ and ½ in. line sizes, with ratings of 75, 100 and 200 cfm, respectively. Price, $17.50; delivery, 3 wk. **Wilkerson Corp, 1656 W Girard, Englewood, Colo.**

Circle 301 on Reader Service Card

Constant volume regulator . . . provides automatic regulation of gas or air output, regardless of fluctuating supply pressures. Output volume can be adjusted from 5 to 180 scfh at pressure differentials of 1 to 25 psi. Price ranges from $71.10 to $87.77, depending on quantity. Delivery, 4 to 6 wk. **George W Dahl Co Inc, 86 Tupelo St, Bristol, RI.**

Circle 303 on Reader Service Card

Non-woven, low-density filter . . . material is based on rayon fiber in a woven matrix made of a vinyl compound. Can be used to remove dusts, mists, fumes, smoke, pollens from air and gases; solids from liquids; separation of miscible liquids; noise absorption. Available in thicknesses from 0.1 to 1 in., in rolls, sheets, die-cut pieces or fabricated parts. Pore size also variable. Depending on metal, price ranges from 5 to 25¢ per sq ft; delivery, from shelf to 4 wk. **Hollingsworth & Vose Co, E Walpole, Mass.**

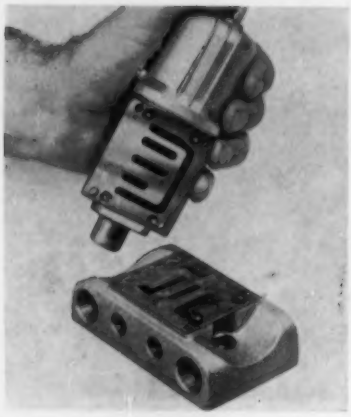
Circle 304 on Reader Service Card

Fasteners have offset recess that is said to provide extra width "shoulders" at point of greatest stress. Bolt made of heat-treated alloy steel with this type of head is said to have withstood 300 in.-lb torque per ¼-28 thread. Can be seated with standard driving equipment, fitted with special offset bits. Available as machine screws, bolts, self-tapping screws in all standard metals, as well as

. . . CONTINUED ON PAGE 106

A-286, Inconel X and titanium B120VCA. Sizes available range from 2-56 up to 1 in. dia. Bolt described above is about $23 per 1000 for 15,000 or more. Other prices quoted on application. 6 to 8-wk delivery. **Aer-O-Line Mfg & Supply Co, 3110 Winona Ave, Burbank, Calif.**

Circle 305 on Reader Service Card



Solenoid-operated air valves

include single and double-solenoid three-way, four-way and four-way-five-port types, in ¼, ⅜ and ½ in. sizes. Valve bodies plug into prewired bodies and bases, and solenoids are interchangeable among valves of same port size. Valves can be set to either locked-in or locked-out position, permitting manual cycling for machine setup. Solenoids have encapsulated coils and are rated 0.8 amp inrush, 0.125 amp holding for ¼-in. size. Priced from $40 to $100. From stock after Dec. 1. **Mechanical Air Controls, 10030 Capital Ave, Detroit 37.**

Circle 306 on Reader Service Card

Silicon rectifier . . .

consists of standard polarity junction back-to-back with reverse polarity unit. This is said to permit doubling voltage with only small dimensional increase. Peak inverse voltages range from 700 to 1600 v, with max dc output of 750 ma (25 D). Max forward voltage drop is 1.8 v; recovery time is 5 microsec. ⅜ x 1⅜ in. In production quantities, $5 to $12. About 2-wk delivery. **Bradley Semiconductor Corp, 275 Welton St, New Haven 11, Conn.**

Circle 307 on Reader Service Card

Wedge-base indicator lamp . . .

about size of jelly bean, withstands ambient temperature up to 900 F because it has no basing cement. Because base is all-glass, it is also smaller and lighter than lamp it replaces. For use in push-pull sockets. Rated for 12 v. Has about 500-hr life. Measures 1$\frac{1}{16}$ in. over-all. **General Electric Co, Nela Park, Cleveland 12.**

Circle 308 on Reader Service Card

Epoxy coating . . .

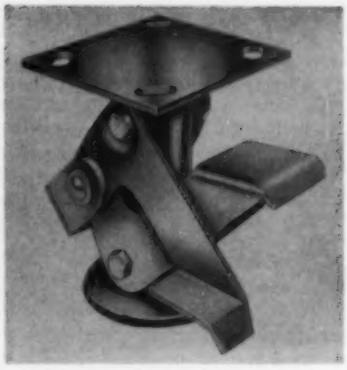
reported not to fail despite prolonged exposure to high-intensity gamma radiation is based on resin amine-cured system. Coating is two-part cold-curing vehicle requiring a curing agent to complete chemical reaction that hardens resin. **Shell Chemical Corp, 50 W 50th St, New York 20.**

Circle 309 on Reader Service Card

Size 5 servo motor . . .

has 1-in. over-all length. Delivers a no-load speed of 9500 rpm and has stall torque of 0.09 in.-oz and theoretical acceleration of 45,000 rad/sec^2. Total power input is 3.5 w. 400 cps unit is said to perform efficiently in temperatures of —67 to 302 F. Encapsulated servo motor is protected against severe shock, vibration and humidity. Weighs 0.68 oz. **IMC Magnetics Corp, 570 Main St, Westbury, NY.**

Circle 310 on Reader Service Card



Double-pedal floor lock . . .

utilizes separate compression and retraction springs for locking and unlocking operations. Available for portable equipment in any size from 5¾ to 12 in. over-all height. Extra large bottom disk, spring connected, has oscillating action to compensate for uneven surfaces. **Payson-Harris & Reed Inc, 2916 W Jackson Blvd, Chicago 12.**

Circle 311 on Reader Service Card

Pressure transducers . . .

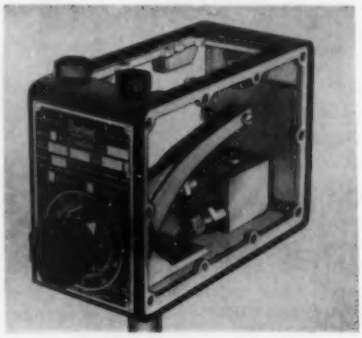
with accessible recalibrating terminal boards are said to withstand severe environmental conditions. Available in pressure ranges from 0 to 50 through 0 to 5,000 psig; and in bridge impedances of 50 to 2,000 ohm. Sensitivity is said to be 3±0.015 milliv per v with total errors of less than 1% of full scale. Dimensions are 3.26 x 0.98 in. sq. **Standard Controls Inc, 1130 Poplar Pl, Seattle 44.**

Circle 312 on Reader Service Card

Hydraulic check valves . . .

are spring-loaded cone type valves for in-line installation. Flared-end model for connecting JIC 37° flared tubing is available in sizes from ⅜ through 1¼ in. OD tubing; model with female pipe thread ports are offered in sizes from ¼ through 1¼ IP. Rated flow is 3 through 50 gpm. Recommended operating pressure is 3,000 psi max; cracking pressure may either be 5 or 65 psi. **Parker Hydraulics Div, Parker-Hannifin Corp, 17325 Euclid Ave, Cleveland 12.**

Circle 313 on Reader Service Card



Pneumatic temperature control

has differential expansion actuating tube that allows operation from sub-zero to 2000 F. Essentially a temperature transmitter, it provides air pressure proportional to temperature and is used for direct operation of air-operated diaphragm valves, motors, dampers or similar equipment. **Burling Instrument Co, 16 River Rd, Chatham, NJ.**

Circle 314 on Reader Service Card

Multicircuit toggle switch . . .

contains four poles, yet occupies less than 1 cu in. of below-panel space. Bat handle is maintained in one of three positions with center position off. Each pole is rated 6 amp, 125 to 250 v ac, 30 v dc, resistive, and 3 amp, 30 v dc, inductive. Weighs about 1 oz. **Electrosnap Corp, 4218 W Lake St, Chicago 24.**

Circle 315 on Reader Service Card

Silicon zener regulators . . .

priced under $1 meet commercial equipment requirements for simplified, reliable, low-voltage regulation. Line consists of single anode and twin anode units. Single anode regulator has reverse breakdown voltage of 6 v ± 1 v and max dynamic impedance of 15 ohm; twin anode regulator has max dynamic impedance of 20 ohm at same reverse breakdown voltage. Both types are rated at 10 milliamp dc.

. . . CONTINUED ON PAGE 108

Earthmoving muscles from tubes of steel

A construction site springs to life as earthmoving equipment tugs, scoops, heaves and rips away at the earth's skin. It's grueling work!

That burly dozer. It's precision built! It's strong! Its massive blade can tear the side out of a hill. Yet, it's nimble, too. In spite of a crab-like figure, it can stop with a jolt, back off, spin, dig in and charge with the force of a galloping rhinoceros.

Power is jammed into these machines. That's why they're built with the toughest, most durable materials in the world. For years, leading manufacturers have chosen USS National Seamless Mechanical Steel Tubing for hydraulic cylinders, tractor pins, bushings and more than 100 other vital parts in earthmoving, rockmoving, grading and all types of heavy mobile equipment. *Why?* Because National Seamless Tubing is ideal for the fabrication of machine parts subject to bruising performance and long wear.

USS National Seamless Mechanical Steel Tubing is another product from the world's largest manufacturer of tubular materials. For more than 80 years, National Tube has been foremost in building and industrial pipe applications. For more information, write to National Tube Division, United States Steel, 525 William Penn Place, Pittsburgh 30, Pa.

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USS

National Tube Division of United States Steel

Columbia-Geneva Steel Division, San Francisco, Pacific Coast Distributors
United States Steel Supply Division
United States Steel Export Company, New York

CIRCLE 107 ON READER SERVICE CARD 107

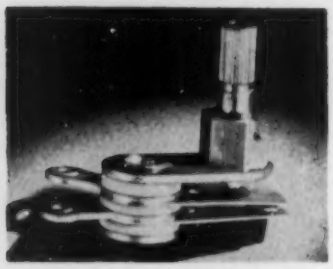
Operate in temperatures of −58 to 176 F. In volume production quantities, regulators are as low as 99¢; 1 to 99, $1.80 each. **Hoffman Electronics Corp, 930 Pitner Ave, Evanston, Ill.**

Circle 316 on Reader Service Card

Longer cartridge heaters . . .

in lengths up to 24 in. or more, in ⅜, ½ or ⅝ in. dia are said to deliver five times as much heat as conventional units. Ratings to 40 to 200 w per sq in. of radiating surface are said to be possible. Temperatures are dissipated through high-temperature sheath. **Vulcan Electric Co, 88 Holten St, Danvers, Mass.**

Circle 317 on Reader Service Card



Inexpensive thermostat . . .

for use on appliances and other apparatus as overheat control, timing and controlling device. Current flowing through bimetal, or temperature of ambient air, or both, actuate bimetal element, breaking circuit. As device cools, bimetal returns to normal position, reclosing contacts. Available in adjustable or non-adjustable styles. Normally rated at 5½ amp on 110 to 120 v ac. **Norwalk Thermostat Co, 52 Woodlawn Ave, Norwalk, Ohio.**

Circle 318 on Reader Service Card

Integral 3-way valve . . .

of signal monitor for pressure limit protection has trip point adjustable from 1 to 100 psig with 0.25 psi repeatability. Can be reset after signal pressure is restored to about 10% above trip setting. Equipped with remote pneumatic trip connection, which makes possible independent tripping from remote point or automatic tripping when air signal exceeds predetermined pressure. **Geo W Dahl Co Inc, 86 Tupelo St, Bristol, RI.**

Circle 319 on Reader Service Card

Corrosion-resistant alloy . . .

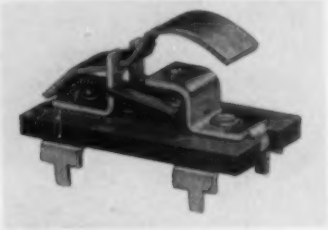
is reported to withstand attack by phosphoric acid at all concentrations and temperatures up to and including a boiling 85% solution. Alloy and its welded structures are said to offer resistance to a wide range of sulfuric and sulfurous acid solutions, to nitric acid, to salt water, and to such boiling organic acids as acetic, phthalic and maleic. **International Nickel Co Inc, 67 Wall St, New York 5.**

Circle 320 on Reader Service Card

Silicone sealant sets . . .

to tough, rubbery solid without addition of catalyst or heat. Resiliency and adhesion remain virtually unchanged at operating temperatures from −70 to 500 F. Compound becomes tack-free within 1 hr and completely cured within 24 hr. Experimental quantities are available to aircraft and missile manufacturers at present. **Dow Corning Corp, Midland, Mich.**

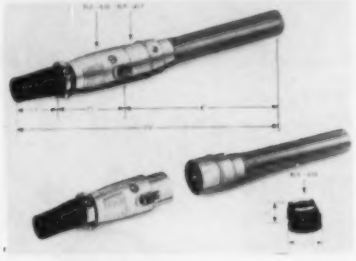
Circle 321 on Reader Service Card



Miniature switch . . .

offers special terminals that facilitate insertion in printed circuit applications. Positive over-travel stop is provided, along with over 50 actuator variations. Measures ¼ x ½ x 1 in. Rated 10 amp at 125 v ac, 5 amp at 250 v ac, and ¼ hp at 125 to 250 v ac. **Cherry Electrical Products Corp, 1650 Deerfield Rd., Highland Park, Ill.**

Circle 322 on Reader Service Card



Magnetic switch . . .

is a sensing device housed in an epoxy resin shell. Features quick-disconnect plug. Min magnetic field transient time of 8 millisec is needed to activate switch. Sensing device is for industrial applications. Over-all length is 5⅛ in. **Electronic Products Div, Post Machinery Co, 175 Eliot St, Beverly, Mass.**

Circle 323 on Reader Service Card

Miniature differentials . . .

in shaft sizes of 3/64, 1/16 and 1/8 in., using precision bevel gears, are available from stock. Stainless steel and aluminum end gears are offered in 96, 120 and 200 pitches with teeth ranging from 100 to 600. Load rating is 10 in.-oz. Max recommended operation speed is 1,000 rpm on ball bearing unit. Available in ball and oilless bearing units, priced at $60 and $42, respectively. **Pic Design Corp, Sub Benrus Watch Co Inc, 477 Atlantic Ave, East Rockaway, NY.**

Circle 324 on Reader Service Card

Chemical-resistant Zippertubing . . .

is made from aluminized silicone rubber impregnated glass cloth. Recommended for wires and cables in hot areas up to 600 F. Immediate delivery. **Zippertubing Co, 752 S San Pedro St, Los Angeles 14.**

Circle 325 on Reader Service Card

Microminiature diode . . .

is reported to withstand shocks of 20,000 times gravity. Weighs 14.09 milligrams compared with 160 milligrams for silicon diode. Molecules of silicon crystal are chemically bonded with surface elements that serve as protective coating. Nine units now in production range in price from $6.50 to $15.50. **Pacific Semiconductors Inc, 10451 W Jefferson Blvd, Culver City, Calif.**

Circle 326 on Reader Service Card

Hydraulic cylinders . . .

rated for 1500 and 3000 psi in sizes from 1½ through 5 in. bore dia are available with fixed or adjustable cushioning. Double and single acting styles are offered with stroke length to customer specifications. Tapered cups mounted on each side of the piston provide cushioning by passing over cylinder ports to restrict exit flow of fluid that gradually increases back pressure against piston. **Lanseair Development Corp, 8 N Main St, Clintonville, Wis.**

Circle 327 on Reader Service Card

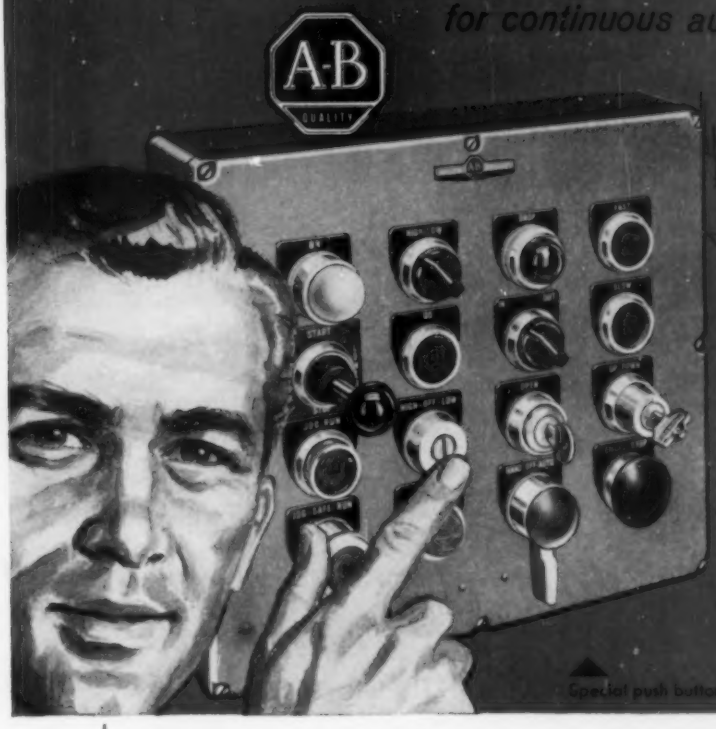
Standard power control . . .

unit regulates up to 3 kw of power. Utilizes solid state thyratrons and its own control amplifier. Provides complete solid state system from logic input to power-handling output. 13½ x 9 x 4 in. unit is particularly suitable where adjustable volt-

. . . CONTINUED ON PAGE 110

AUTOMATION BEGINS HERE

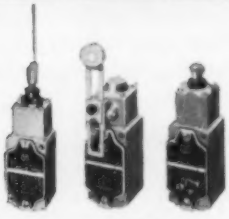
. . . Insist on Allen-Bradley accessories for continuous automatic production



In this broad line of Allen-Bradley accessories, each and every unit carries the traditional A-B trademark of *quality* that stands for trouble free operation. Rugged construction, and maintenance free, silver alloy contacts provide the reliability that is essential to the continuous operation of *your* automatic production machines.

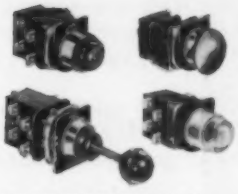
Profit from the experience of the leading machine tool builders . . . insist on Allen-Bradley *quality* motor control *all the way!*

Special push button panels can be assembled to your specifications

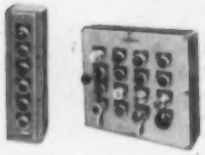


OILTIGHT LIMIT SWITCH
Bulletin 802T with sealed heads and bodies. Various operators.

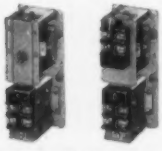
PRECISION LIMIT SWITCH
Bulletin 802 oiltight. Responds to very small operator travel.



OILTIGHT CONTROL UNITS
Bulletin 800T. Choice of push buttons, lights, and switches.

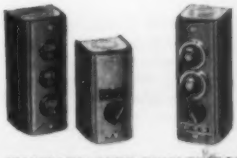


OILTIGHT CONTROL STATIONS
Bulletin 800T for up to 16 units in die cast aluminum enclosure.



PNEUMATIC TIMERS
Bulletin 849. Reliable and accurate. For on-delay or off-delay.

OILTIGHT PRESSURE CONTROL
Bulletin 836. For hydraulic systems with pressures to 5000 psi.



STANDARD DUTY PUSH BUTTONS
Bulletin 800. Up to three units, also pilot lights and switches.

FOOT SWITCH
Bulletin 805. In rugged die cast housing for toughest service.

ALLEN-BRADLEY

Member of NEMA

QUALITY MOTOR CONTROL

Allen-Bradley Co., 1329 S. First St., Milwaukee 4, Wis. In Canada: Allen-Bradley Canada Ltd., Galt, Ont.

CIRCLE 109 ON READER SERVICE CARD 109

ANNOUNCING

GRANODINE 663

FIRST AUTOMATED IRON PHOSPHATE PROCESS! *and it's "cold," too!*

NEWEST PRE-PAINT TREATMENT FOR STEEL

AUTOMATED GRANODINE 663—the industry's first—takes the human element out of quality control . . . replaces it with 100 percent electronic line control, every hour of every day! You get positive, electronic vigilance on the line that adds up to savings in time, labor and chemicals—yet overall coating uniformity and quality never varies!

COLD GRANODINE 663—the coldest yet—means on-the-line savings of 50 percent or more in heating dollars! Typical heat savings range from up to $12,000.00 per year on large volume lines, to $7,500.00 and $5,000.00 yearly on intermediate and smaller spray lines when compared to the cost of typical hot processes.

Put your phosphate processing on a more productive basis with the first completely automated phosphating line in the metalworking industry. Write, wire or phone your local AMCHEM representative for further information on cost-saving, time-saving Granodine 663!

Write for Bulletin 1698 on Granodine 663—contains eye-opening quality control data that will interest your company's financial experts!

AMCHEM

Automated

GRANODINE

another chemical development of

AMCHEM PRODUCTS, INC., Ambler 20, Pa.

(Formerly American Chemical Paint Co.)

Detroit, Mich. • St. Joseph, Mo. • Niles, Calif. • Windsor, Ont. • Amchem and Granodine are registered trade marks of AMCHEM PRODUCTS, INC.

Check these Automated GRANODINE 663 Features...

- ✓ Automated—for round-the-clock quality and bath stability!
- ✓ Cold—for substantial heat savings!
- ✓ Lowest coating weight consistent with top quality!
- ✓ Powder-free coatings, continuous and adherent!
- ✓ Sludge-free bath!
- ✓ No oxidizing accelerators required!
- ✓ Readily soluble powder form, cheaper to ship, easier to store!

...and call your Amchem representative today!

AMCHEM

Automated GRANODINE

another chemical development of
AMCHEM PRODUCTS, INC., Ambler, Pa.
(Formerly American Chemical Paint Co.)

Detroit, Mich. • St. Joseph, Mo. • Niles, Calif. • Windsor, Ont. • Amchem and Granodine are registered trademarks of AMCHEM PRODUCTS, INC.

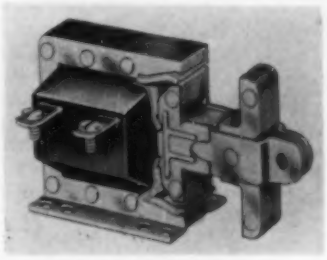
age, dc or ac power, is required, for dc motor speed control, heat control and similar applications. Control, Div of Magnetics Inc, Butler, Penna.

Circle 328 on Reader Service Card

Heavy-duty cylinders . . .

for 2000 psi hydraulic service (3000 psi, non-shock) are available in 12 bore sizes from 1½ through 12 in., with 23 different mounting styles and four different rod ends. S-P Mfg Corp, 30201 Aurora Rd, Solon, Ohio.

Circle 329 on Reader Service Card



Double-T solenoids . . .

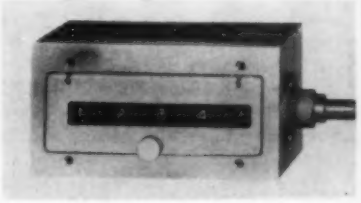
have coil windings and terminals protected by layer of epoxy resin. As plunger stroke decreases, gap is bridged by extra T section on plunger, providing additional pull at ⅛ point and preventing drop in power. Four sizes offering 12 sets of electrical characteristics are available for constant or intermittent duty, 60 cps circuits, 110 or 220 v. Max stroke ranges from ⅜ to 1¼ in., depending on model. Controls Co of America, Industrial and Commercial Controls Div, 9555 Soreng Ave, Schiller Park, Ill.

Circle 330 on Reader Service Card

Heavy-gage polyethylene sheets . . .

in black and natural-clear are available in 20, 28 and 32-ft seamless widths. Offered in thicknesses up to and including 15 mils. Gering Plastics Div, Studebaker-Packard Corp, 7th St & Monroe Ave, Kenilworth, NJ.

Circle 331 on Reader Service Card



112-AB-4-2

Shaft-driven counters . . .

for telemetering shaft rotation and position, have electrical contacts that cor-

(Continued on page 112)

YOU GET *Lower* VACUUM PUMP MAINTENANCE *Costs* and Increased Vacuum with the **HILCO OIL RECLAIMER**

HILCO
OIL RECLAIMER
For complete oil reclaiming. Removes solids, acids and volatile impurities; moisture, solvents, gases, etc. by heat-vacuum process.

A simple, economical and efficient method of restoring contaminated lubricating and sealing oil to the full value of NEW OIL. The HILCO will produce and maintain oil free of solids, water, gums and acids in a continuous, all-electric, automatic operation.

Be Sure of CLEAN OIL in your HIGH VACUUM PUMPS

KEEP YOUR HYDRAULIC SYSTEM *Clean* with

HILCO HYDRAULIC OIL FILTER

No More Varnish and Sludge Deposits
No More Flushing and Manual Cleaning
No More Frequent Oil Changes
No More Accumulation of Dirt
Filter life up to a year eliminates usual frequent draining, refilling of systems.

Write for complete details in the free bulletin at no obligation . . .

THE HILLIARD Corporation
198 West Fourth St. Elmira, N. Y.
In Canada
UPTON-BRADEN-JAMES LTD.

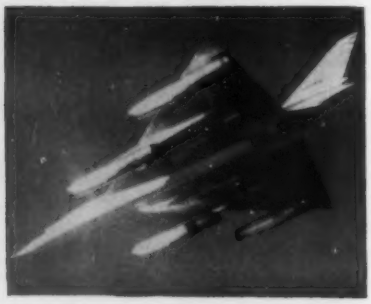
B.F.Goodrich

Over 200 kinds of adhesives

TODAY, B.F.Goodrich makes over 200 kinds of adhesives. Most of these are in regular use in one or more of our customers' plants. Some are tailored to specific jobs, others cover a range of many applications.

Adhesives made by B.F.Goodrich will bond almost any materials you can name—joining them to themselves or each other. Sometimes, adhesive bonding is the only practical method of fastening. In other cases, adhesives often have special advantages—high strength, less weight, lower cost or greater freedom of design.

Brake linings, supersonic planes, helicopter rotor blades, curtain walls for buildings, for example, have all proven to be stronger, safer when bonded together with B.F.Goodrich adhesives. High-strength adhesives took the place of 500,000 rivets in the B-58 supersonic bomber (picture).



Each month, perhaps a dozen new formulations join the ranks of our adhesives as we work with industry to find ways to improve product design and production techniques.

Here are some recent examples:

B.F.Goodrich has perfected an adhesive that permits vinyl-coated sheet steel to be deep-drawn—stretched as much as 35 per cent without weakening the bond or damaging the coating.

Two new adhesives have been developed by B.F.Goodrich for bonding polystyrene foam. One is ideal for use with foamed-in place polystyrene. The other is recommended for bonding pre-foamed polystyrene shapes to themselves or to steel, aluminum, formica and other materials.

For bonding some materials that in the past stubbornly refused to stick together, B.F.Goodrich has a new group of rubber-like adhesives. Synthetic films, such as nylon, polyethylene and cellophane can now be bonded to all kinds of metal as well as to paper, wood, glass, foils and plastics.

With so many stock adhesives to choose from, and so many other special ones possible, it may be a problem to find the best one. You can get more information by writing to B.F.Goodrich.

When you write, give details. It's surprising how often small details help us recommend the one adhesive that does the job.

How will you apply the adhesive? Spray, roller coat, extrusion or brush? What materials are to be joined? Can heat and pressure be used? Any temperature limitations? Method of assembly (present or proposed)? Is metal used? If so, how is the metal pretreated?

How strong must the bond be? Must it have heat resistance? How much? Chemical resistance? Are there any requirements for taste, odor, toxicity, color? Any other requirements?

Just write to *Department M-727, B.F.Goodrich Industrial Products Co., Akron 18, Ohio.*

B.F.Goodrich *industrial adhesives*

respond with each number on each wheel, or are furnished with precision resistors mounted between contacts. Counters, in each of the two models, are available with 3, 4, or 5 wheels, each indexed from 0 to 9. **Photocon Research Products, 421 N Altadena Dr, Pasadena, Calif.**

Circle 332 on Reader Service Card

Miniature power connectors . . .

are rectangular units with center screw-lock and closed entry contacts. Body molded from glass-filled diallyl phthalate. Can be supplied in 152, 104, 78 or 34 contacts. **DeJur-Amsco Corp, 45-01 Northern Blvd, Long Island City 1, NY.**

Circle 333 on Reader Service Card

Snap-action switches . . .

in pin plunger, lever action and panel mounting models have silver contacts that provide stability against momentary high over-load. UL-rated for 15 amp at 125 v ac; 10 amp at 250 v ac; ½ hp at 125 to 250 v ac. **Controls Co of America, Industrial & Commercial Controls Div, 9555 Soreng Ave, Schiller Park, Ill.**

Circle 334 on Reader Service Card

High-strength belts . . .

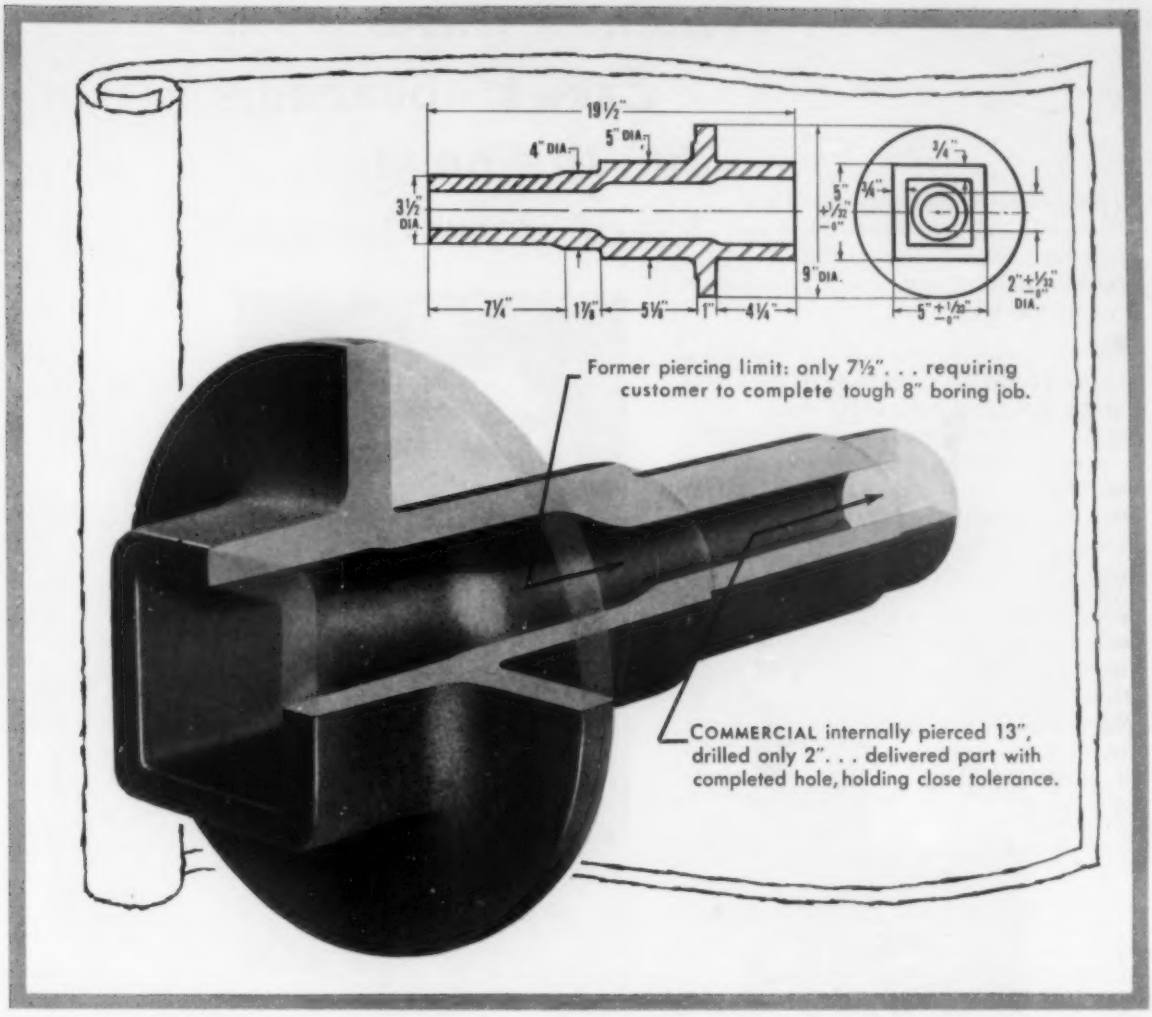
and sheaves are said to handle up to three times hp of conventional V-belt drives occupying same space. Number of belt cross-sections is reduced from five to three. Entire range of drive requirements from 1 to 1,500 hp is covered by cross-sections with dimensions of $\frac{3}{8}$ in. wide x $\frac{7}{16}$ in. deep; $\frac{5}{8}$ x $\frac{1}{2}$ in.; 1 x $\frac{7}{8}$ in. Cost savings to 30% are reported. **T B Wood's Sons Co, Chambersburg, Penna.**

Circle 335 on Reader Service Card

Subminiature pressure switch

monitors constant pressure over temperature range of −85 to 400 F, with accuracy of 0.5 for −85 to 185 F and 1.5 psi from 185 to 400 F. Employs hermetically sealed snap-action switch. Available in actuating pressure range of 5 to 30 psia, SPST or SPDT. Rated 28 v

(Continued on page 116)



"Task-Forging" Pierces Holes 60% Deeper

Advanced upsetting techniques at COMMERCIAL now permit internal piercing of forgings well beyond the commonly-accepted 7 to 1 length-to-diameter limit.

Good example of new advantages: a 39 lb. rear axle spindle. Formerly the customer had to drill 8" of the 1½" I. D. after forging—a tough job with a close concentricity tolerance.

Now "Task-Forged", the part leaves COMMERCIAL's versatile, integrated plant with completed bore . . .with a substantial savings in metal and machining.

For COMMERCIAL's "Task-Forge" engineering-upsetting-boring team, the improvement was a "1-2-3" routine:

(1) The square end, flange and round end were upset from a 2¾" bar of SAE 8640 steel.

(2) The internal hole of varying I. D. was punched 13". . . over 60% deeper than before!

(3) The remaining 2" of the 1½" I. D. was precision drilled in the same plant.

Like to see what the "Task-Forging" concept can do for you? Just send a sketch or drawing of your part to Dept. G-46.

COMMERCIAL SHEARING & STAMPING COMPANY

YOUNGSTOWN 1, OHIO

COMMERCIAL shearing & stamping

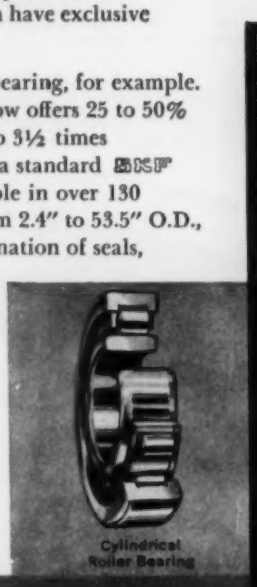
CIRCLE 113 ON READER SERVICE CARD 113

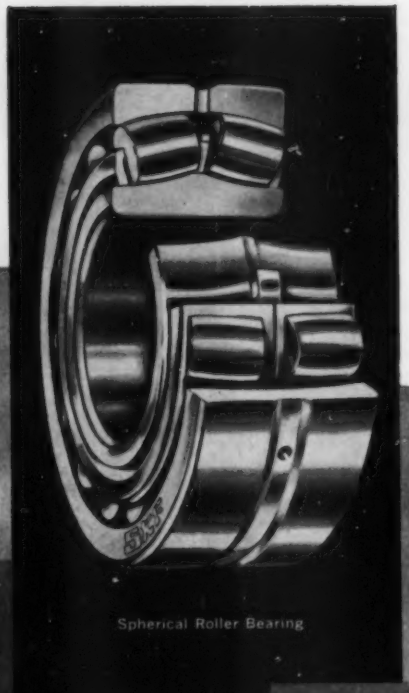
Which of these SKF bearings fits the needs of your design?

SKF continually produces all of these standard bearings—in countless sizes and variations—in production quantities. And practically all of them have exclusive features that benefit you.

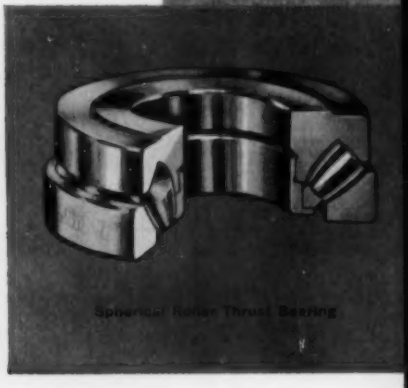
Take the spherical roller bearing, for example. Recently re-designed, it now offers 25 to 50% increased capacity and 2 to 3½ times longer service life. Yet it's a standard SKF bearing—promptly available in over 130 standard sizes ranging from 2.4" to 53.5" O.D., with every possible combination of seals, shields and adaptors to meet your specifications.

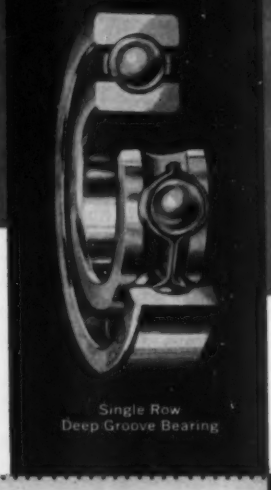
But why not get full details on this—or any other— SKF bearing? Each is made to do an efficient, economical job for you. Call any one of the 25 SKF sales offices today. 5906

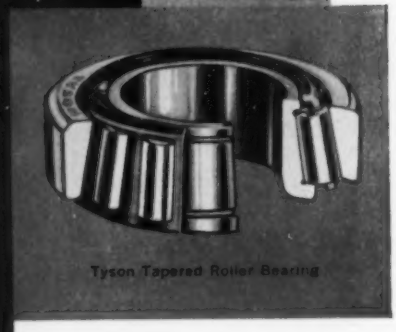

Cylindrical Roller Bearing


Spherical Roller Bearing

Angular Contact Bearing


Spherical Roller Thrust Bearing


Single Row Deep Groove Bearing


Tyson Tapered Roller Bearing

Spherical, Cylindrical, Ball, and Tyson Tapered Roller Bearings

EVERY TYPE—EVERY USE

SKF

SKF INDUSTRIES INC. PHILADELPHIA 32, PA.

*REG. U. S. PAT. OFF.

CIRCLE 115 ON READER SERVICE CARD→

COORS PRECISION CERAMIC PART ENDS CORROSION OF PRESSURE SWITCH

Ceramic valve for respirator so sensitive it can be actuated by infant's breath

Bird Oxygen Breathing Equipment, Inc., of Palm Springs and San Francisco, manufactures a new, compact, precision respirator used by anesthesiologists in delicate surgical procedures and by physicians to treat lung diseases like asthma and emphysema.

Operation of the instrument is dependent upon the extreme sensitivity of a pressure switch . . . a switch so sensitive that the slightest intake of breath causes the respirator to operate and begin breathing for the patient . . . so sensitive that it operates from the breath of a weakened patient, even a new-born infant. The respirator must be able to work perfectly even after years of disuse on the shelf, under conditions of sporadic operation, and under conditions of regular exposure to oxygen, ozone and moisture.

Metal and alloy parts corrode. With every metal or alloy that Bird designers tried as parts for the pressure switch valve, the minute amount of moisture present in the gases used caused an electrolytic action that resulted in adhesion of the metal plunger to the sleeve—a slight seizing, but enough to prevent the valve from operating with the necessary sensitivity. Oxidation was also a problem—the slightest roughening of the smooth surfaces prevented valve from functioning.

Coors Ceramic valve eliminates corrosion. These problems with metal valves were eliminated when Bird used Coors High Strength Alumina Ceramic (type AD-85) in place of metals. Because Coors ceramics do not corrode or seize, and because properly finished ceramic surfaces have a very low coefficient of friction, the pressure switch works perfectly. Also, because of the extreme hardness of the Coors Ceramic, there is little or no wear—the precise fit of the ceramic plunger and sleeve is retained throughout the operating life of the respirator, tested to 20-million cycles of perfect operation!

During manufacture of the ceramic parts, Coors holds tolerances to 0.000025" on both the O.D. of the shaft and the I.D. of the sleeve. Difference in diameters between shaft and sleeve is held to 0.0001-0.0003".

Coors High Alumina Ceramic is a fine engineering material for applications requiring a high degree of corrosion resistance or abrasion resistance . . . also for applications that require high strength under conditions of extreme heat . . . or for any combination of these conditions.

Coors Complete Engineering Service. Coors offers a complete field engineering service to assist you in utilizing these high strength ceramics to the best advantage. **Write for complete Technical Data Sheets on Coors Ceramics and facilities.** The following Coors Sales Engineers are ready to help you with your current ceramic problems:

REGIONAL SALES MANAGERS

West Coast.....William S. Smith, Jr.
EM 6-8129—Redwood City, Calif.

Midwest.....John E. Marozeck
FR 2-7100—Chicago, Ill.

Central.....Donald Dobbins
GL 4-9638—Canton, Ohio

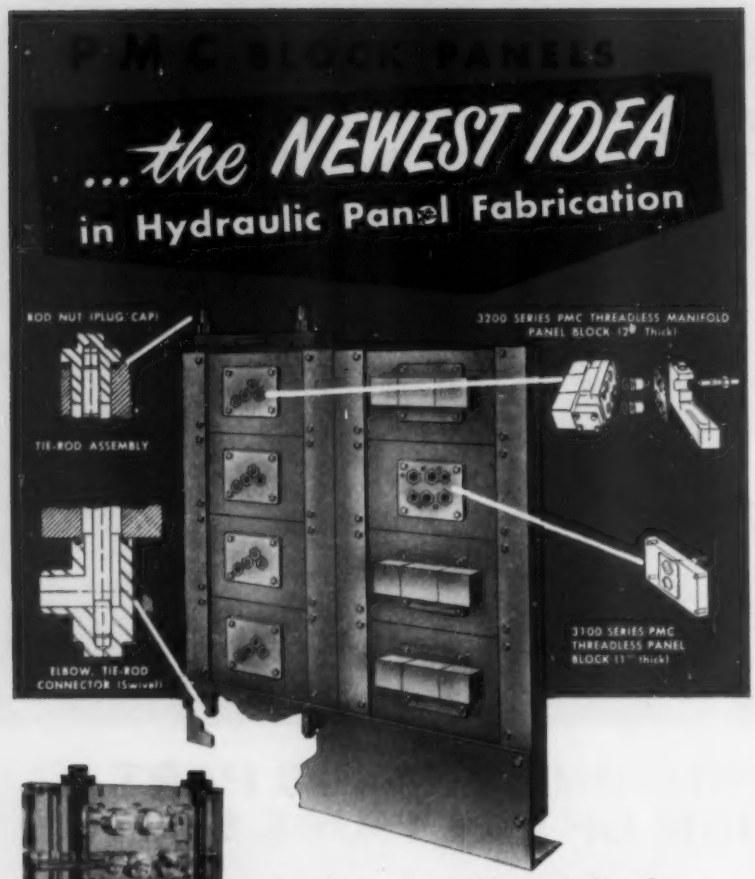
East Coast.....John J. McManus
UL 7-6010—Brooklyn, N. Y.

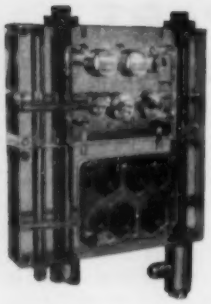
New England and New York.....Warren G. McDonald
FR 4-0663—Schenectady, N. Y.

Coors

COORS PORCELAIN COMPANY

600 Ninth Street, Golden, Colorado


P M C BLOCK PANELS
...the NEWEST IDEA
in Hydraulic Panel Fabrication
ROD NUT (PLUG CAP)
TIE-ROD ASSEMBLY
3200 SERIES PMC THREADLESS MANIFOLD PANEL BLOCK (2" Thick)
3100 SERIES PMC THREADLESS PANEL BLOCK (1" thick)
ELBOW, TIE-ROD CONNECTOR (Swivel)



Produces a self-contained, ready to install panel assembly *Easily, Quickly, Economically*

P M C block panels are a result of PETCH engineers recognizing the need to reduce external piping . . . develop universal components for varied system combinations . . . reduce costs and maintenance. P M C panel design approaches specially engineered, cross-drilled, multi-valve panel blocks as far as possible; yet retains standard, reuseable, fully flexible P M C block components. P M C block design utilizes standard, unit size, extruded hi-tensile aluminum — large enough to accept one hydraulic valve with internally manifolded pressure, return and drain lines held together with tie-rods to produce a self-contained ready to install panel assembly. Blank panel blocks are available to fill out a rectangular arrangement.

STANDARDIZED
•
REUSEABLE
•
FULLY FLEXIBLE
•
LEAKPROOF
•
CUTS MAJOR EXTERNAL PIPING BY 50%

Ask to have a PETCH representative call on you.

PETCH PMC

463 York Road
Detroit, Michigan

MANUFACTURING COMPANY

dc, 110 v ac and 5 amp, resistive. Weighs less than 1.8 oz. Measures $1\frac{33}{64}$ x $\frac{7}{8}$ in. dia. **Newark Controls Co, 15 Ward St, Bloomfield, NJ.**

Circle 336 on Reader Service Card

Rapid air-dry resin . . .

for industrial finishes is said to set tack-free in about 5 min. and to harden into tough, glossy finish without baking. Resin is a pure oxidizing oil-modified alkyd. Enamels in every color from white to black, including metallics, can be made with the resin. **Archer-Daniels-Midland Co, 700 Investors Bldg, Minneapolis 2.**

Circle 337 on Reader Service Card

Low-cost purifier . . .

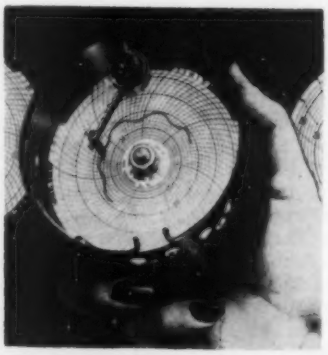
has liquid storage reservoir for keeping air and steam lines free of moisture and condensate. Unit is blown down periodically by manually-operated drain valve. Reservoir capacity varies from $\frac{1}{2}$ pt for the $\frac{1}{4}$ in. size to $6\frac{1}{2}$ pt for the 2-in. model. For applications up to 400 psi service and 500 F. **V D Anderson Co, Div International Basic Economy Corp, Dept LCR, 1935 W 96th St, Cleveland 2.**

Circle 338 on Reader Service Card

150 gpm control valves . . .

for hydraulic service operating to 2000 psi are offered in 2 and 3-spool versions. For raising, positioning, rotating, holding or lowering control. Valves have open center, series parallel circuit with integral individual load check valve for each cylinder port. **Parker Hydraulics Div, Parker-Hannifin Corp, 17325 Euclid Ave, Cleveland 12.**

Circle 339 on Reader Service Card

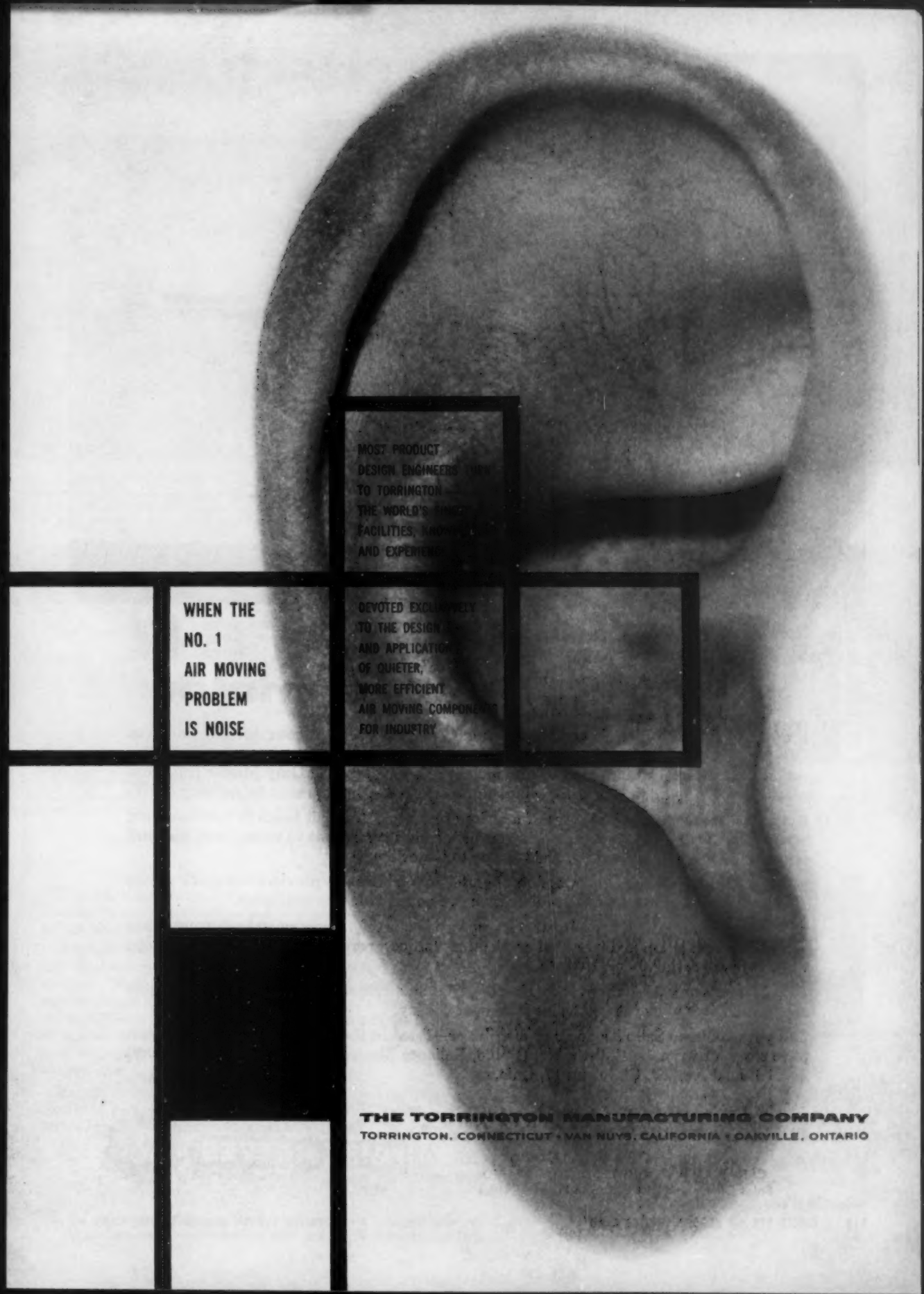


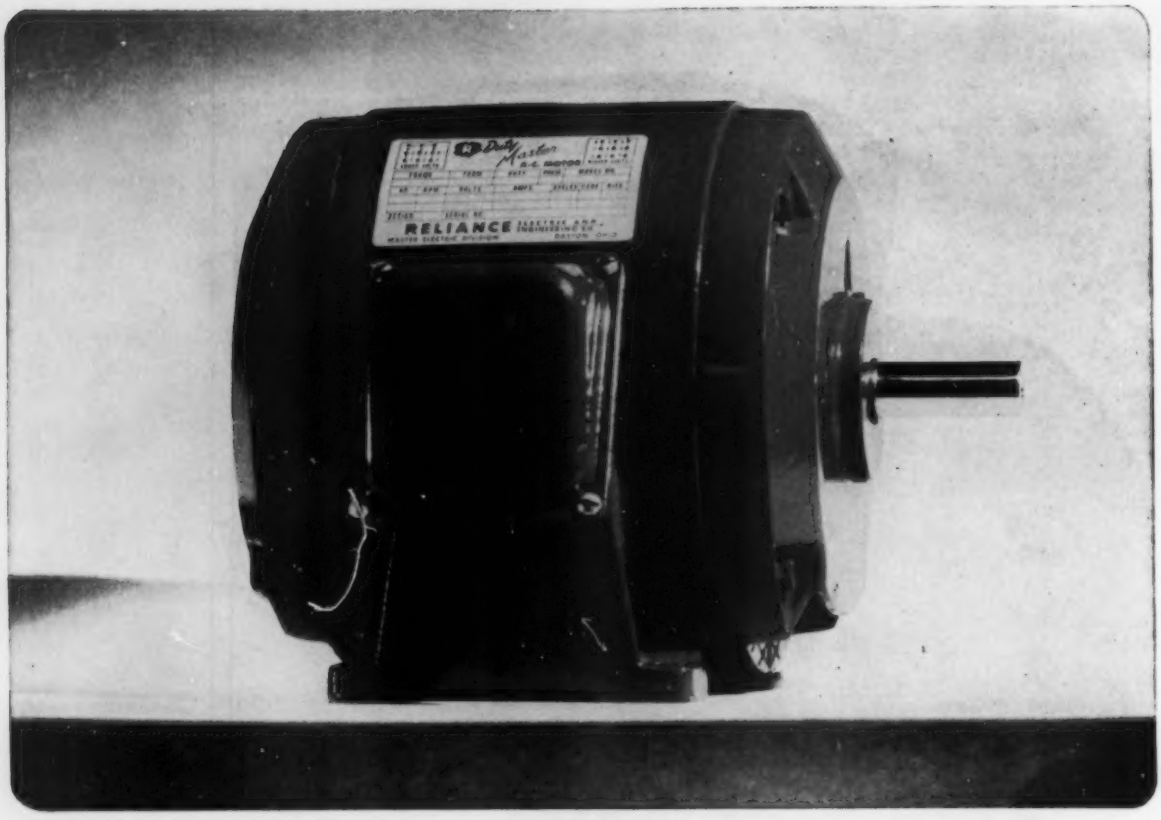
Recording thermometer . . .

is driven by spring-wound clock movement made in two different time ranges, either 24 hr or 7 day, and two temperature ranges, 20 to 220 F or —40 to 160 F. Uses dry scriber which records on $3\frac{1}{2}$ in. circular chart. Measures $2\frac{7}{8}$ x $3\frac{13}{16}$ in. dia

(Continued on page 120)

Circle 117 on Reader Service Card→


MOST PRODUCT
TO TORRINGTON
AND EXPERIENCE
WHEN THE
NO. 1
AIR MOVING
PROBLEM
IS NOISE
DEVOTED EXCLUSIVELY
TO THE DESIGN
AND APPLICATION
OF QUIETER,
MORE EFFICIENT
AIR MOVING COMPONENTS
FOR INDUSTRY
THE TORRINGTON MANUFACTURING COMPANY
TORRINGTON, CONNECTICUT • VAN NUYS, CALIFORNIA • OAKVILLE, ONTARIO



DUTY MASTER

a brand new a-c. motor

Product of Reliance Electric and Engineering Company and its Master Electric Division, Duty Master's new design gives users better protection from the inside out, simplified lubrication, better response and improved all around performance. The Duty Master line, from protected open, to totally enclosed, explosion-proof, 1 to 250 hp., is ready for delivery *NOW*.

Duty Master's insulation, by means of a series of multiple dips and bakes in thermosetting varnish plus final protection in finishing enamel, makes it resistant to water, acid, dirt and other contaminating elements . . . adds years to motor life.

"Metermatic" lubrication regulates flow of grease to the bearing—provides automatic grease relief. No danger of over-or under-lubrication . . . no maintenance headaches.

Duty Master's low inertia rotor has faster response in starting, stopping and reversing. This, plus better ventilation and increased accelerating torques, permits frequent starts and stops without over-heating.

Duty Master's new design proves conclusively that all a-c. motors are *not* alike . . . that this new motor gives users the best value in industry today.

Call your Reliance Sales Engineer or distributor—listed in the Yellow Pages—for the complete story, or write for Bulletin No. B-2106, Reliance Electric and Engineering Company, 24701 Euclid Avenue, Cleveland 17, Ohio.

B-1636

RELIANCE ELECTRIC AND ENGINEERING CO.

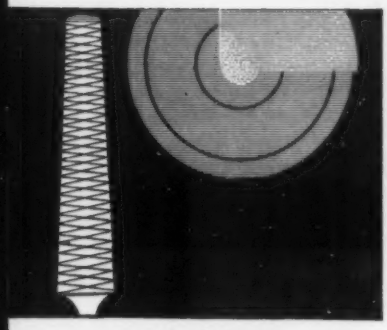
DEPT. 3011A, CLEVELAND 17, OHIO
CANADIAN DIVISION: TORONTO, ONTARIO
Sales Offices and Distributors in Principal Cities

MASTER REEVES R

CIRCLE 119 ON READER SERVICE CARD→

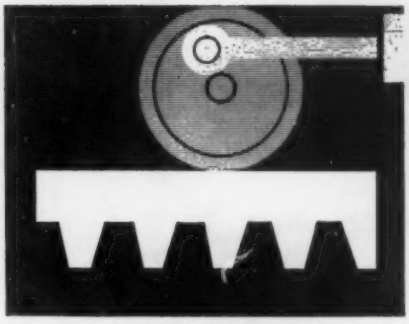
specify urethane elastomers

for functional end products with maximum engineering properties



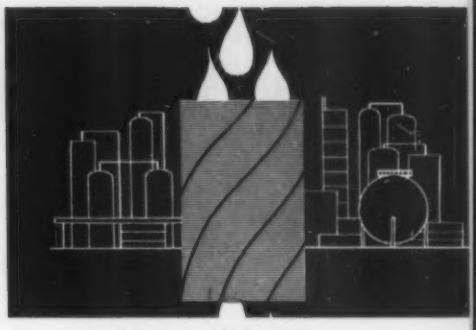
wear resistance

The combination of high tensile strength, abrasion resistance and tear strength results in long service life for parts cast of urethane elastomers.



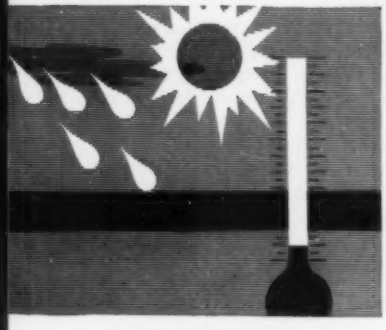
controlled friction

Urethane elastomers have a high coefficient of friction ideal for drive units, or can be modified to be self-lubricating.



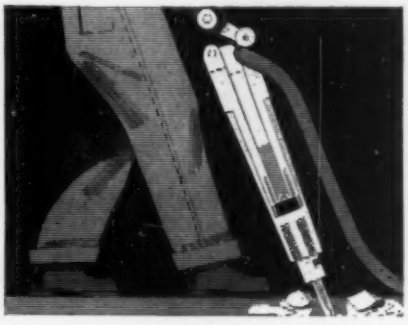
solvent resistance

Urethane elastomers have superior solvent resistance. Oil immersion at 130°C for 100 hours shows little loss of properties.



aging resistance

Urethane elastomers have excellent resistance to ozone, oxygen and weathering for longer service.



shock absorption

Urethane elastomers are unique in their combination of high load-bearing, vibration dampening and shock absorbing properties. Rebound elasticity ranges from 45% to 60%.

hardness with elasticity

Properties of high hardness, with high flexibility enable urethane elastomers to "bridge" a basic material gap between metals and rubbers.

Urethane elastomers offer opportunities to build into new or existing products a combination of desirable properties never before possible with a single material.

Urethane elastomers with a hardness range of 60 to 100 Shore "A" durometer, are tough yet elastic, have excellent tensile strength, high resistance to abrasion and oxidation. Softer grades exceed the strength characteristics of natural and synthetic rubbers; while harder urethane elastomers provide a structural and engineering material which combines high hardness and elasticity with other controlled properties, including high or low coefficient of friction.

Simple and inexpensive molds may be used to cast close tolerance parts incorporating undercuts, slots, tapers and integral inserts that require no further finishing.

For complete details, use the handy coupon

The superior properties described in these references are obtainable only in urethane elastomers formulated with Mobay's Multrathane chemicals.

Mobay supplies basic chemicals and technology for manufacturing urethane elastomers.

MOBAY

First in Urethane Chemistry

Mobay Chemical Company
Dept. P-14 Pittsburgh 34, Pa.

I would like more information about the properties, uses and suppliers of cast urethane elastomers formulated from "Multrathane" chemicals.

Name

Title

Company

Address

City, Zone, State E-1

A reliable source of Cherry blind rivets and tools is waiting to serve you at the other end of your telephone line in more than 75 cities throughout the United States and Canada.

This network of Townsend jobber-distributors provides you with a ready inventory of self-plugging and pull-thru rivets together with a full range of hand and power-actuated setting guns and other installation tools.

In addition, the jobber-distributor in your area is qualified to give you expert assistance in selecting the proper size and style of rivet for your particular application.

Your jobber-distributor now stocks Townsend Cherry blind rivets in steel, aluminum alloy, Monel and copper—in 3/32", 1/8", 5/16", 1/4" and 9/32" diameters—in a wide range of grip lengths and a variety of head styles. For the name of the jobber-distributor nearest you, write to Engineered Fasteners Division, P.O. Box 71-D, Ellwood City, Pa.

Townsend Company

Engineered Fasteners Division

ELLWOOD CITY • PENNSYLVANIA

In Canada: Parmenter & Bulloch Manufacturing Company, Limited, Gananoque, Ontario

weighs 14 oz, $37.50, FOB Los Angeles. From stock. **Pacific Transducer Corp, 11836 W Pico Blvd, Los Angeles 64.**

Circle 340 on Reader Service Card

Footswitch . . .

is available in five different standard switch ratings and arrangements. Cast iron housing has black wrinkle finish. Dimensions are 4¾ x 2¾ x ⅞ in. Weighs 1 lb. Delivery, stock to 10 days. Price ranges from $7.85 to $8.15. **Vemaline Products Co, 388 N. 11th St, Prospect Park, NJ.**

Circle 341 on Reader Service Card

Instrument cabinets . . .

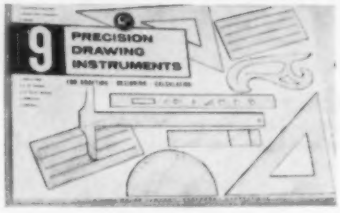
of thermosetting and thermoplastic materials are said to be self-extinguishing and designed to meet UL approval tests. Cabinets are styled so that they will not be identified with any particular brand. **Tech-Art Plastics Co, Box 739, Morristown, NJ.**

Circle 342 on Reader Service Card

Miniature enclosed rheostat . . .

has light-weight, drawn aluminum housing that is dust-tight. Three rheostat terminals are brought out to corresponding terminals on back panel. Exclusive of shaft, enclosure measures 1 3/4 in. dia x 1 3/32 in. long. Rated 12½ w at 40 F. **Ohmite Mfg Co, 2661 Howard St, Skokie, Ill.**

Circle 343 on Reader Service Card



Drawing-computing set . . .

includes ruler, T-square calibrated in inches and centimeters, 6-in. protractor calibrated in ½°, French curve, 10-in. 30 to 60° triangle, 45 to 90° triangle, engineer's scalemaster 6 in. and architect's scalemaster 6 in. and 6-in. slide rule for pocket or desk. Priced at $5, postpaid. **Edmund Scientific Co, Barrington, NJ.**

Circle 344 on Reader Service Card

Wide-range thermometer . . .

is an all-purpose portable instrument for electronically measuring temperature. Features include pushbutton range selection, direct readings in degrees Fahrenheit, ½ F accuracy over major portion of range, 12 ranges from −425 to 800 F, full interchangeability of probes and instruments.

(Continued on page 123)

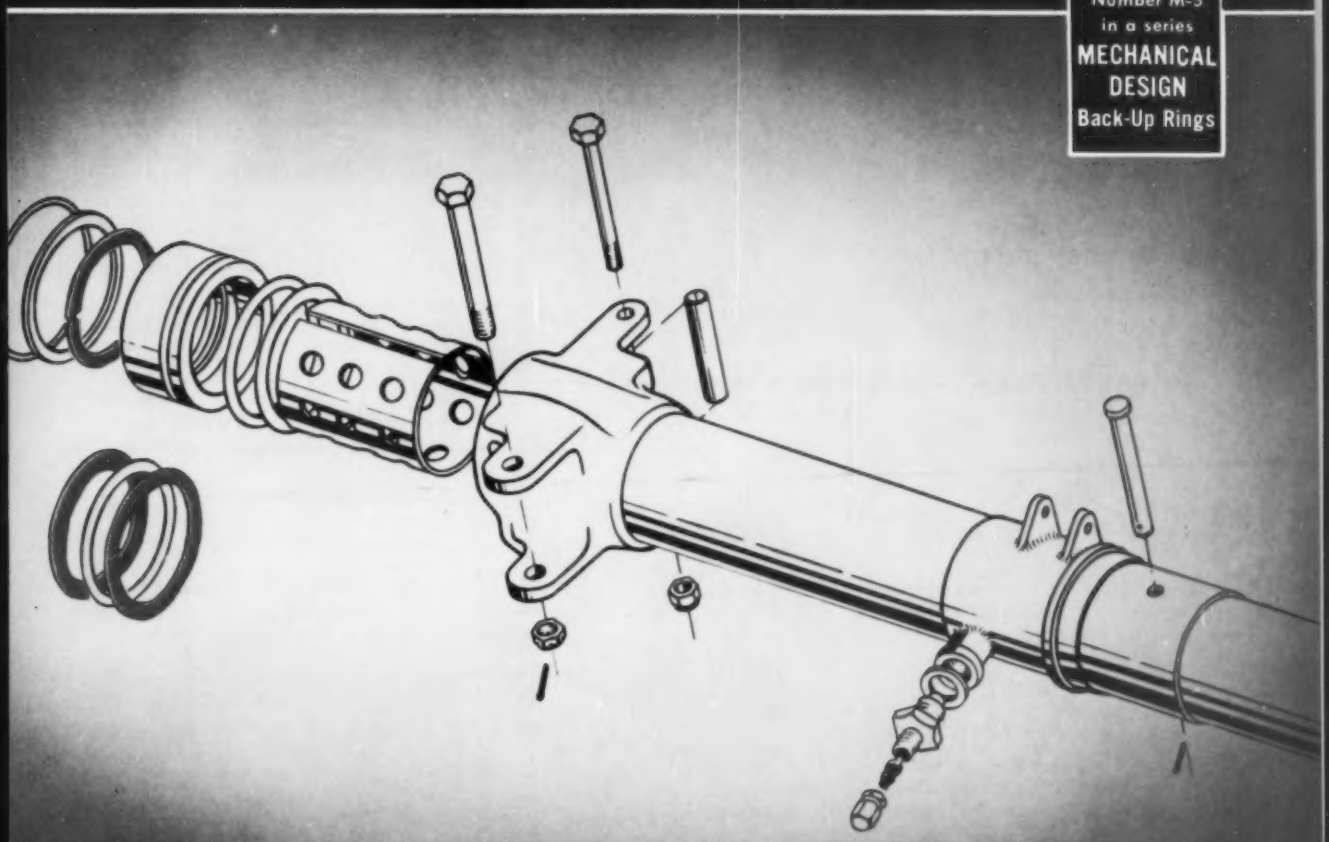
DU PONT

ENGINEERING FACTS ABOUT

TEFLON®

FLUOROCARBON RESINS

Number M-5
in a series
MECHANICAL
DESIGN
Back-Up Rings



Back-up rings of TFE resins reduce frictional drag . . . improve seal efficiency

The hydraulic system shown above is used in the landing gear and nose gear of commercial aircraft. According to the manufacturer, the use of back-up rings fabricated from a TEFLON TFE resin results in reduced frictional drag, improved operation and lower over-all costs.

The exceptionally low coefficient of friction of TFE fluorocarbon resins—less than .04—is one of the reasons why back-up rings made of TEFLON help assure efficient seal operation in any application. In operation, some of the TFE resin is deposited from the back-up rings to the rubber O-rings, which provides a further reduction of frictional drag. Back-up rings of TFE resins also increase the operating life of the seal, because they prevent extrusion of O-rings and reduce spiral twisting. They provide longer life, safer and more reliable performance and reduced maintenance problems in everyday seal designs, as well as in applications that involve adverse conditions, such as extremes of temperature or corrosion problems.

On the next page you will find additional information on the properties of TEFLON TFE resins as they relate to back-up rings, and detailed considerations of design opportunities they provide in many types of seal applications.

TEFLON is Du Pont's registered trademark for its fluorocarbon resins, including the TFE (*tetrafluoroethylene*) *resins discussed herein.*

OVER

Back-up rings of TFE resins: DESIGN CONSIDERATIONS

The problem of O-ring extrusion

In general, O-rings provide effective sealing in wide ranges of temperatures and pressures, with the added advantages of sealing in both directions and making possible space savings. One drawback of O-rings, however, is their tendency to extrude into the clearances under fluid pressure, as shown in Figure 1.

O-ring extrusion can be prevented by the use of back-up rings of TFE resins. These thin rings are much harder than are rubber O-rings, yet they do deform enough to provide zero clearance for the O-ring. Figure 2 shows a rule-of-thumb chart that may be used as a guide on static or dynamic O-rings of rubber to indicate whether or not anti-extrusion rings should be used. There are many additional reasons why TEFLON TFE resins are rapidly replacing other materials for use in back-up rings. The following advantages relate to back-up rings as anti-extrusion devices:

Back-up rings of TEFLON TFE resins

1. Back-up rings of TFE resins are easier to make and buy to the close tolerances required in a precision sealing installation, as compared with leather, the previous standard material. The result is increased reliability, uniformity and reproducibility.

2. Back-up rings of TFE resins are compatible with all hydraulic fluids. They are essentially chemically inert and do not embrittle or fibrate.

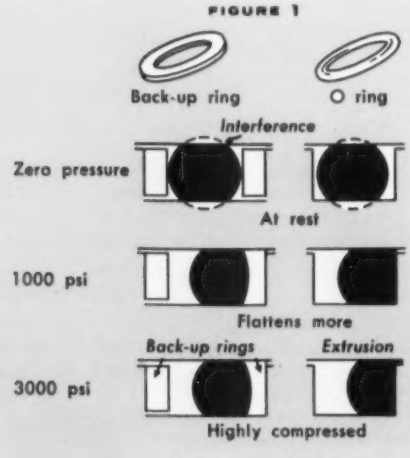
3. Installation is easier; rings of TFE resins are usually scarf-cut and can be slipped over a shaft; there is no right and wrong side; and they require no oil soaking or drying out to install.

4. TFE resins retain their outstanding properties up to 500°F., and reinforced back-up rings of TFE resins are being used at even higher temperatures.

5. The exceptionally low coefficient of static friction of TFE resins—0.04—reduces break-away friction. TFE resins deposit a molecular coating which in turn imparts low friction to mating surfaces.

6. Yet with all these advantages, back-up rings of TFE resins can be installed at a *cost saving* over back-up rings of leather.

FIGURE 1



Additional performance advantages

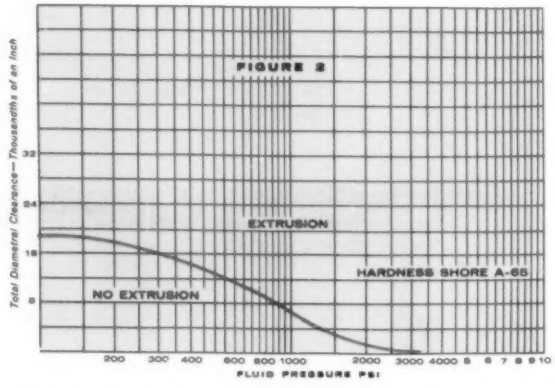
As TFE resins become more and more widely used in anti-extrusion rings, additional advantages from the use of TFE resins in back-up rings have become evident. And, even if extrusion does not present a problem, the advantages of using a back-up ring of a TEFLON TFE resin can greatly improve your O-ring seal installation.

1. Longer O-ring life. The majority of O-ring failures occur either by nibbling or spiral failure. The zero clearances provided by TEFLON TFE resins in back-up rings reduce the tendency to nibbling; and spiral failure is reduced because of the molecular coating of TEFLON TFE resins deposited on the cylinder surface, permitting the rubber to slide evenly without slipping or rolling.

2. Reduction in break-away friction of O-rings. The molecular layer of TFE resin deposited on cylinder walls decreases the break-away friction of rubber O-rings, which otherwise may be 50 to 100 per cent higher than the running friction.

3. Ease of removal of old O-rings. The anti-stick properties of TEFLON TFE resins prevent sticking of old rubber in the groove, thus reducing replacement time and insuring proper seating of the new rubber seal.

4. Savings in machining. The standard recommended 32 rms surface finish on ring grooves is an expensive machining operation. When using back-up rings of a TEFLON TFE resin, this requirement is not as critical, and the groove may be left in the as-machined condition, normally 64 to 120 rms. Savings in machining alone often pay for the small cost of a back-up ring of a TEFLON TFE resin.



FOR MORE INFORMATION . . .

Further details on the properties and design characteristics of TFE fluorocarbon resins, and their application to back-up rings and all types of seals, may be obtained from your local supplier. You'll find him listed under "Plastics—Du Pont" in the Yellow Pages. Supplementary engineering data on the properties of TFE resins is available on request from your supplier or from: E. I. du Pont de Nemours & Co. (Inc.), Advertising Department, Room T-3611, Nemours Bldg., Wilmington 98, Delaware.

In Canada: Du Pont of Canada Ltd., P.O. Box 660, Montreal, Quebec.

DU PONT

TEFLON®

TFE-FLUOROCARBON RESINS

BETTER THINGS FOR BETTER LIVING . . . THROUGH CHEMISTRY

Power supply can be self-contained C battery or 60 cps, 110 v ac source. Instrument weighs 12 lb with battery and measures 10 x 9 x 6 in. Components are said to be operated well below peak ratings. **Trans-Sonics Inc, Burlington, Mass.**

Circle 345 on Reader Service Card

Punched tape block reader . . .

for standard 1 in., five to eight hole paper or mylar tapes is designed to read fixed block of information in any number up to 48 lines (up to 384 bits) at once. **Wang Laboratories Inc, 12 Huron Dr, Natick, Mass.**

Circle 346 on Reader Service Card

Miniature tape reader set . . .

includes transmitter-distributor, motor, base and cover. Measures 5⅞ x 7½ x 9½ in. Has facilities for sequential output, hundred word per min transmission and reduced power requirements. **Teletype Corp, Dept. SP-8, 4100 Fullerton Ave, Chicago 39.**

Circle 347 on Reader Service Card

Portable temperature potentiometer . . .

in single and double range units are available in any of 20 temperature ranges and four millivolt ranges, all of which are interchangeable. Operator can change range with screwdriver by inserting new circuit panel, a 27½ in. scale and, if necessary, binding post studs. Both potentiometers can provide output in millivolts, equivalent to temperature setting of the instrument, for use in checking similar potentiometers, recorders and controllers. Limit of error is 0.2% of range span. Single-range potentiometer is $270; double-range unit is $330. Delivery to start in Jan '60. **Leeds & Northrup Co, 4934 Stenton Ave, Philadelphia.**

Circle 348 on Reader Service Card

Up to five pickup heads . . .

are used with this torquemeter to measure torque of rotating shafts. Available with ranges covering from 0.1 in.-oz to 500 in.-oz, with accuracy to within 2% of full scale. Torque readings are independent of shaft speeds between 50 and 24,000 rpm, as well as direction of shaft rotation. One-knob calibration adjustment for each torque pickup head provides stability against ambient changes. May be used with most recorders. Over-all design provides over-load protection up to twice rated load. Housings for pickups are 4⅛ to 7 in. long, depending upon range. **Metron Instrument Co, 432 Lincoln St, Denver 3.**

Circle 349 on Reader Service Card

Difficult Teflon* & KEL-F† Moldings Offer No Problems

Our specialty is precision molding where close tolerances, intricate shapes, and where thin wall sections are involved. Garlock's United States Gasket Plastics Division has the personnel, the facilities, the unequalled experience in handling tough fluorocarbon plastics.

Guarantee yourself the best parts, and the right price—ask for a quote on any molding problem concerning TEFLON T.F.E. and KEL-F. Call us, too, for fluorocarbon sheets, discs, tape, rods, tubing, bars, and cylinders from the world's largest and most complete stock.

For Prompt Service, contact one of our 26 sales offices and warehouses in the U.S. and Canada, or write The Garlock Packing Company, Palmyra, New York.

*DuPont Trademark for T.F.E.-fluorocarbon resin
†M.M.&M. Trademark

United States Gasket

Plastics Division of GARLOCK

CIRCLE 123 ON READER SERVICE CARD 123

This is an actual photograph of 1½" Springfield "400" hose.

NOW!

design with large diameter Teflon* hose that bends like this!

$6\frac{3}{4}$"

If you design fluid handling, transfer, or hydraulic equipment, you already know Teflon hose. Wonderful! Except, up to this time larger diameters were not really flexible. But *now* look!

SPRINGFIELD "400" WITH FINGER FLEXIBILITY ONLY TITEFLEX HAS IT!**

- Minimum bend radius: *only 3⅓ times the hose diameter!* Thanks to the exclusive TITEFLEX process.
- Teflon innercore with all its properties. It's tough, lightweight, inert, resistant to corrosion and temperature extremes. Flex life is almost endless.
- Available now up to 2" in diameter, lengths to 25 feet (soon to 50!).
- Fittings prove failure-proof—right up to burst pressure of hose!
- In many cases, a shorter Springfield "400" hose can replace extruded hose at big savings.

Springfield "400" has already made exciting news in scores of applications—new uses crop up every day. How about your field? Our bulletin will set design ideas clicking. Ask your TITEFLEX distributor (see the Yellow Pages) for a copy. Or drop us a line direct.

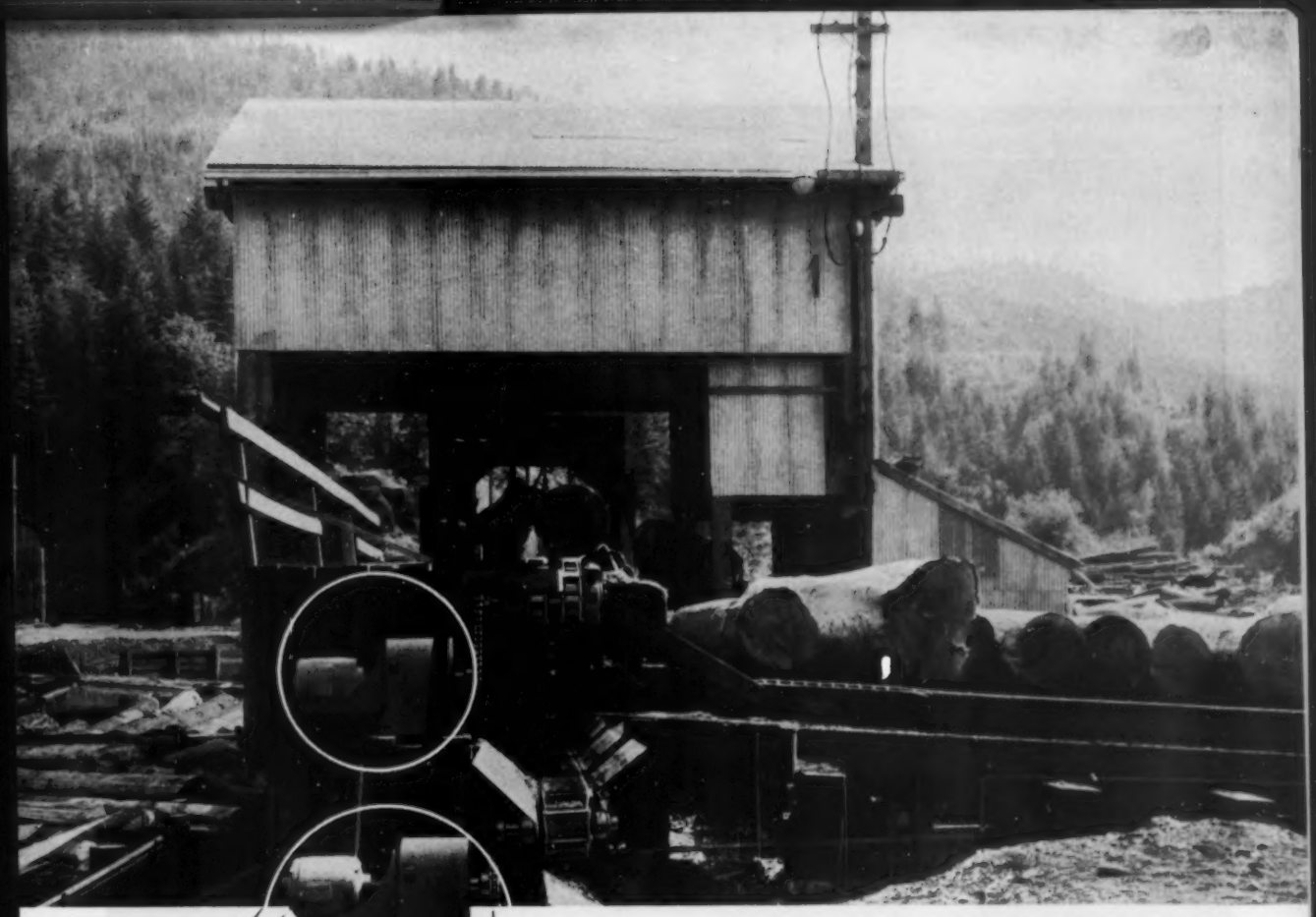
titeflex

Do these Springfield "400" applications suggest anything to you?

TANK, CAR, BARGE, MILITARY VEHICLE application • CHEMICAL • HIGH TEMPERATURE AIR • PLASTIC COMPOUND • HOT TAR AND ASPHALT • LIVE STEAM • CORROSIVE FLUID • HIGH TEMPERATURE HYDRAULIC SYSTEMS • AIRCRAFT: high temperature fuel and lubricating systems • MISSILE: fuel and oxidizer lines of vehicles and ground support •

titeflex inc. springfield mass. PACIFIC DIVISION • SANTA MONICA • CALIFORNIA

*Teflon is a duPont trademark
**T.M. of Titeflex, Inc., Pat. Pending



FALK Motoreducers driving log conveyor and refuse conveyor at the modern mill of The Bohemia Lumber Company, Culp Creek, Oregon.

FALK *all-steel* Motoreducers give you longer service life

Whether your load conditions are normal or heavy, the extra rigidity of all-steel construction (more than twice that of cast iron) maintains better alignment of revolving elements under load...a vital factor in prolonging the service life of gears and bearings.

And if your installations are subject to shock loads, or accidental external impacts, you're way ahead when you install Falk All-Steel Motoreducers. These rugged units do not destroy themselves by tearing off their feet under jamming overloads, nor are their housings subject to cracks which both dissipate the vital lubricant supply and allow revolving elements to get out of alignment.

All-steel construction is one of the built-in extras that you get in Falk Motoreducers. Others include: (1) 12 to 15% reserve load-carrying capacity in the gears (by AGMA standards), thanks to exclusive Falk extra-depth, high pressure angle helical gears; (2) maximum mechanical efficiency (98½% per gear mesh, under full load); (3) your choice of standard units (horizontal, vertical or right angle) to fit your precise requirements.

HORSEPOWER RANGE: to 75 hp . . . STANDARD OUTPUT SPEEDS: 780 rpm (high) to 1.2 rpm (low).

Prompt delivery from distributor stocks, or from warehouse or factory. Ask your Falk Representative or Authorized Falk Distributor for ***Bulletin 3100.***

THE FALK CORPORATION, MILWAUKEE 1, WIS.

MANUFACTURERS OF QUALITY GEAR DRIVES AND FLEXIBLE SHAFT COUPLINGS

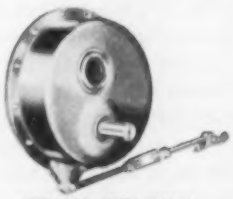
Representatives and Distributors in most principal cities

FALK

. . . a good name in industry

Take your choice of all-steel drives when you specify Falk

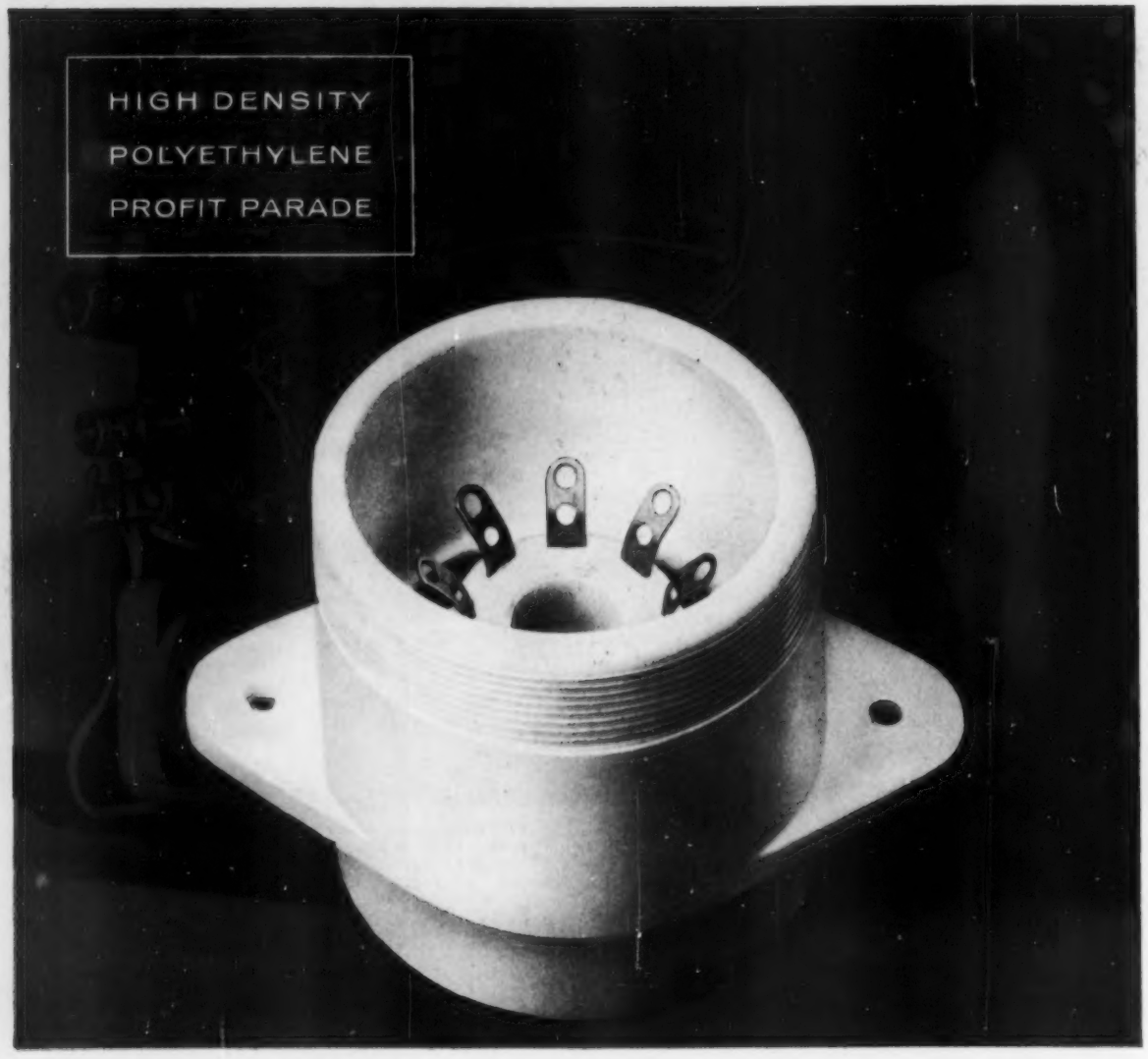
THE FALK ALL-MOTOR MOTOREDUCER
...the original All-Motor unit



THE ALL-STEEL FALK SHAFT MOUNTED DRIVE

Torque ratings to 41,000 lb-in at low speed shaft. Also available in flange-mount design.

FALK and ALL-MOTOR are Registered Trademarks.



New Part Holds the Line Against Rising Costs

If you are battling to keep costs down you should know about Grex high density polyethylene. Reduction in manufacturing costs is one of the many advantages in specifying parts made of this new Grace plastic.

The TV tube socket shown here helps hold the line against rising costs for many leading manufacturers. It is injection molded for significantly less than is possible to produce competing sockets which can only be made by more costly fabricating methods.

Consider these other advantages of Grex. It is hard, stiff and tough enough to take a beating in installation or use without breaking, cracking or chipping. It is the only thermoplastic that can be boiled or frozen without losing its shape or impact strength. It has outstanding electrical insulating properties, is resistant to most corrosive chemicals and provides flame-retardance if required, as in this electrical application.

If these unique properties bring a Grex application to mind, decide to call in the experts on high density polyethylene now. Grace has the production facilities, technical service and experience to help put your product in the Grex profit parade. We're easy to do business with.

Grex is the trademark for W. R. Grace & Co.'s Polyolefins.

W.R. GRACE & CO.
POLYMER CHEMICALS DIVISION
CLIFTON, NEW JERSEY

Tube socket for TV sets demonstrates outstanding Grex electrical properties.

Take a look at the technical background on this socket for an idea of what you can expect to gain by specifying Grex for electrical equipment.

Electrical properties. High density polyethylene is one of the most effective electrical insulating materials available. The Grex compound in this socket has a dielectric strength (short time) of 475 volts per mil for ⅛" thickness. With such high resistivity the wall sections were kept thin for fast cycles and economical production. Another advantage of specifying Grex is the stability of its dielectric constant: this socket is stable from 60 cycles per second all the way up to 1,000,000 cycles per second.

Molding considerations. Injection molding of Grex resulted in considerable cost savings over compression molding of thermosetting materials. In order to meet electrical equipment safety requirements, C-1012 Grex flame retardant compound was chosen for the job. Of the five Grex flame retardant compounds available, C-1012 has the highest melt index—6.0—to provide the best flow characteristics and the impact strength needed for the socket.

Mechanical properties. The resiliency and high impact strength of Grex are particularly valuable in this application. While breakage due to riveting socket ears to chassis is a major problem with sockets made of other materials, high impact Grex sockets hold breakage to a minimum. Resiliency simplifies insertion of metal lugs which dig into sockets easily and hold firmly. Resiliency also saves time in installation of threaded caps which are simply pushed over the sockets without stripping threads.

Interested? If you have a job for high density polyethylene count on Grace for help. Now's the time to contact:

Technical Service Department
W. R. Grace & Co., Clifton, N. J.

CATALOGS and BULLETINS

To obtain copies of literature described below, circle corresponding number on postcard inside back cover. For those catalogs and bulletins available only when requested on company letterhead, see page 144.

STRUCTURAL ALUMINUM – Handbook, 6th edition, 420 pp, including 140 tables. Revisions involve changes in text, general up-dating of tables and addition of several new tables. Data on aluminum-magnesium alloys and welded structure design are included. Aluminum Co of America, 789 Alcoa Bldg, Pittsburgh 19.
Circle 350 on Reader Service Card

SELF-LOCKING FASTENERS – Catalog, 20 pp. Describes design of one-piece fastener and gives specifications for entire line. Western Sky Industries, 1301 Cloud Way, Hayward, Calif.
Circle 351 on Reader Service Card

GEAR MOTORS–Book 2747, 48 pp. Discusses functions of gear motors, motorized gears and fluid drives. Provides selection information, dimensions, overhung load ratings and mountings. Also lists such accessories as couplings, backstops and slide rails. Covers service classifications and application information. Link-Belt Co, Dept PR, Prudential Plaza, Chicago 1.
Circle 352 on Reader Service Card

ELECTRICAL PRODUCTS – Catalog, about 64 pp. Illustrates all available products with explanatory text. Specifications include dimensions, range and performance charts. Covers distributors, starting motors, generators, ignition coils, voltage regulators, pump and traction motors, fhp dc motors, relays, solenoid switches and governors. Electric Auto-Lite Co, Toledo 1, Ohio.
Circle 353 on Reader Service Card

ELECTRICAL WIRING DEVICES–Catalog 1959-60, 80 pp. Covers about 1500 electrical items, grouped in categories, cross-indexed for ease of reference. UL and CSA listings as well as Federal specifications numbers are indicated. Eagle Electric Mfg Co Inc, 23-10 Bridge Plaza S, Long Island City 1, NY.
Circle 354 on Reader Service Card

SPECIALTY STEEL–Buyers guide, 40 pp. Contains information on tool and die steels; stainless steels; high-temperature alloys; electronic, magnetic and electrical alloys; special-purpose alloy steels; tubing and pipe and fine wire specialties. Carpenter Steel Co, 317 W Bern St, Reading, Penna.
Circle 355 on Reader Service Card

HIGH-STRENGTH STEEL–Booklet, 24 pp. Properties and characteristics of type H-11 steel. Contains numerous graphs and charts. Allegheny Ludlum Steel Corp, Oliver Bldg, Pittsburgh 22.
Circle 356 on Reader Service Card

MAGNESIUM DIE CASTINGS–Booklet, 8 pp. Gives how, why and where of magnesium die castings and Dow facilities. Dow Metal Products Co, Hopkins Bldg, Midland, Mich.
Circle 357 on Reader Service Card

HP RATINGS FOR COG AND V-BELTS–Bulletin, 16 pp. Presents revised cog and standard V-belt ratings of industrial multiple V-belt line. Also includes information on how to design with new belt ratings. Dayton Rubber Co, Industrial Products Div, Dayton 1, Ohio.
Circle 358 on Reader Service Card

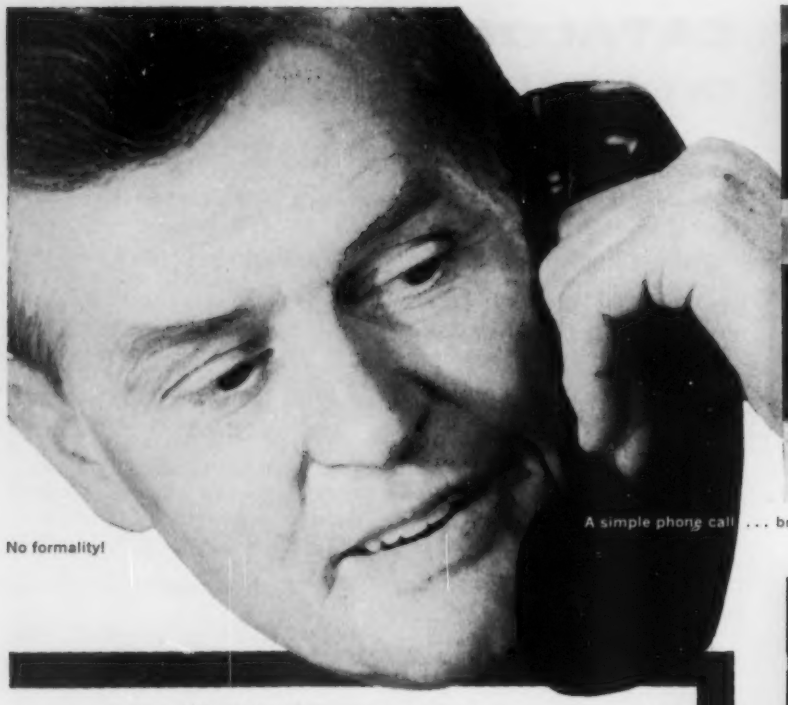
CASTING ALUMINUM–Handbook, 32 pp. Information on various casting processes suitable for aluminum and recommendations for alloy selection. Tabular matter is presented in eight tables. Reynolds Metals Co, Dept PRD-17, Box 2346, Richmond 18, Va.
Circle 359 on Reader Service Card

MINIATURE POWER CONNECTORS–Brochure 1416-659, 20 pp. Specifications and dimensional drawings of series 14 and 16 heavy-duty, rectangular power connectors. DeJur-Amsco Corp, 45-01 Northern Blvd, Long Island City 1, NY.
Circle 360 on Reader Service Card

VACUUM INDUCTION MELTED ALLOYS–Bulletins: on Udimet 700, 8 pp, and Udimet 41 (also known as Rene 41), 12 pp. Covers performance of superalloys, description and chemical composition, physical constants, tables and charts on mechanical properties, isostress curves and information on heat treatment and finishing. Kelsey-Hayes Co, Dept 15, New Hartford, NY.
Circle 361 on Reader Service Card

POWER CONTROL UNITS–Bulletin S-1075, 8 pp. Describes five different control systems designed for proportional or switching control. Discusses applications. Includes illustrations of transfer characteristics, unit schematics and typical servo

(Continued on page 130)



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First, you deal with a Doehler-Jarvis Resident Engineer. Through him you can tap the full production and engineering talent of the most experienced company in die casting . . . no matter how large or small your requirements. Through him you obtain personal day to day liaison that insures maximum production economy through personal attention to your needs and problems.

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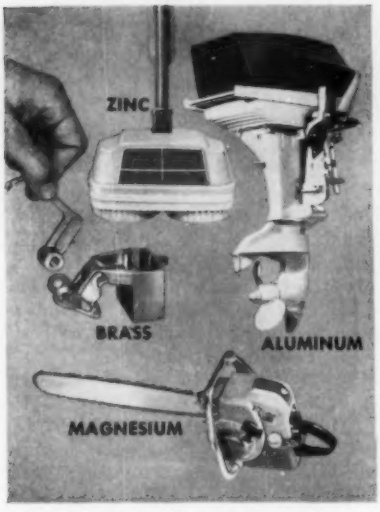

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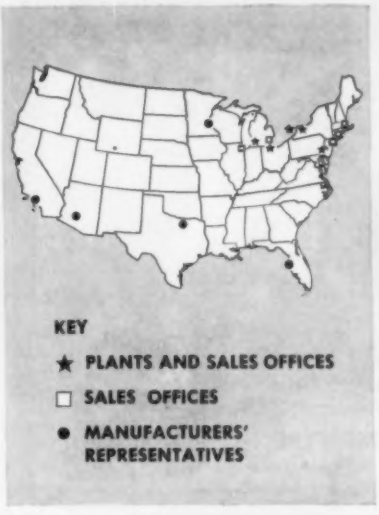

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Doehler-Jarvis has served many companies for more than a quarter century, some for better than 50 years. Proof enough that no other die caster provides more quality, more service and more overall economy to the customer. Ask your Doehler-Jarvis Resident Engineer to tell you how much we are prepared to do to establish equally satisfactory supplier-purchaser relations with you.

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Division of
NATIONAL LEAD COMPANY

CIRCLE 129 ON READER SERVICE CARD

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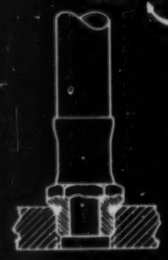
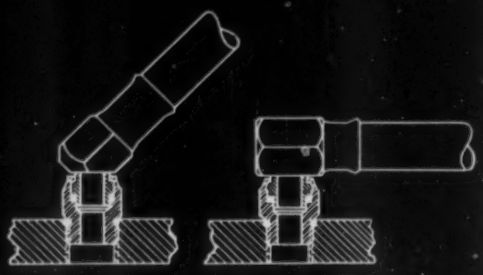
Make them with

ANCHOR SAE STRAIGHT THREAD "O" RING BOSS FITTINGS *and* BOSS TYPE HOSE ASSEMBLIES



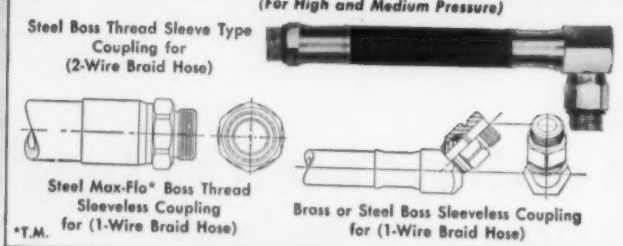


Permanently Applied Anchor Boss Type Couplings attached to high or medium pressure hose and SAE "O" Ring Boss Fittings for direct attachment to any valve body designed to SAE Straight Thread "O" Ring Boss specifications.

A comprehensive line of SAE Straight Thread "O" Ring Boss Fittings for connections.

PLUS ANCHOR BOSS TYPE HOSE ASSEMBLIES

(For High and Medium Pressure)

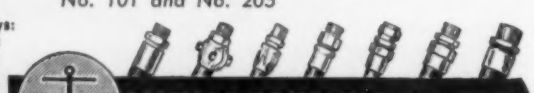

Steel Boss Thread Sleeve Type Coupling for (2-Wire Braid Hose)
Steel Max-Flo* Boss Thread Sleeveless Coupling for (1-Wire Braid Hose)
*T.M.
Brass or Steel Boss Sleeveless Coupling for (1-Wire Braid Hose)

It's amazing what clean, compact hydraulic hook-ups you can make with these Anchor products! You'll appreciate them most when making connections in closely confined areas.

They're neat, orderly and compact always—ready for connection to any valve port designed to SAE Straight Thread "O" Ring Boss specifications. Excessive tightening is not required with the "O" Ring Seal, eliminating leakage danger from cracked and distorted valve seats and threads, and assuring a leak-proof connection.

For complete details write for Anchor Catalogs No. 101 and No. 205

Andy Anchor Says: It's the years of experience that makes every Anchor product a leader of its type.



ANCHOR COUPLING CO. INC.

367 North Fourth St., Libertyville, Ill.
Branch Plants: Dallas, Tex., Plymouth, Mich.

systems employing control units. Magnetic Amplifiers Inc, 632 Tinton Ave, New York 55.

Circle 362 on Reader Service Card

ROOM - TEMPERATURE - VULCANIZING SILICONE RUBBER—Bulletin CDS-170A, 12 pp. Information on product properties and uses of —20, —40, —60, —90 compounds and silicone rubber sponge. General Electric Co, Silicone Products Dept, Waterford, NY.

Circle 363 on Reader Service Card

POLYPROPYLENE FILM – Technical data bulletin, 4 pp. Properties and characteristics of polypropylene film. AviSun Corp, Post Rd, Marcus Hook, Penna.

Circle 364 on Reader Service Card

MINIATURE ELECTRIC EYES–Bulletin 571, 16 pp. Describes applications, equipment and installations. Includes dimensions, circuitry, speed, monitoring and relay information, as well as table covering history and general and special applications. Contains numerous schematics. Photomation Inc, 96 S Washington Ave, Bergenfield, NJ.

Circle 365 on Reader Service Card

SOCKET SCREW PRODUCTS – Bulletin 2338, 8 pp. Presents line of standard socket screw products. Configurations, sizes, materials, design features and proper installation are charted for reference and comparison. Standard Pressed Steel Co, Jenkintown, Penna.

Circle 366 on Reader Service Card

TAPER SEAL VALVES, FITTINGS–Catalog 759, 12 pp. Dimensional information and application data, for stainless steel taper seal valves and fittings designed for pressures to 15,000 psi. High Pressure Equipment Co Inc, Erie, Penna.

Circle 367 on Reader Service Card

MOLDED PACKINGS–Bulletin GTR-759, 8 pp. Contains descriptions, service recommendations, specifications and application data on T-shaped molded packings. Typical applications are shown in schematic diagrams and cutaway installation drawings. Greene, Tweed & Co, North Wales, Penna.

Circle 368 on Reader Service Card

PHOSPHOR BRONZE ROD–Bulletin, 8 pp. Physical, mechanical and fabricating properties and common fabrication processes for free-cutting phosphor bronze rod are discussed. Bridgeport Brass Co, Bridgeport 2, Conn.

Circle 369 on Reader Service Card

ELASTOMER COATED FABRICS – Brochure, 12 pp. Describes elastomer

(Continued on page 134)

FACTS ON **KEYSTONE** POWDER METALLURGY

THE PLACE OF GEARS

IN KEYSTONE POWDER METALLURGY

A few years ago, the simplest gear shapes seemed remarkable in themselves as they came chuting from the powder metal presses. Those uncomplicated spur gears exemplified all the tenets of powder metallurgy—low cost, high volume parts that required no expensive machining, and delivered excellent service in the right applications.

But our progress has moved swiftly in sintered gears since those pioneer days. The development of better materials has opened up many new medium- and high-strength applications to powder metal service. Imaginative tool engineering and press design have made possible the widest range of gear types . . . clusters, bevels, pinions, sectors, helicals . . . saving progressively more money as designs become more complex.

Today, gear production at Keystone is major in importance. We can meet your requirements to the dot in type, material, quantity, delivery and performance. In brief, we're geared to serve. Call us!

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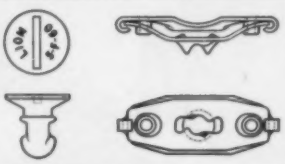
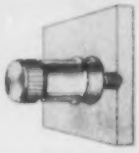
Captive Quick-Opening Fasteners:

Southco standards provide many benefits at low cost for access through doors, covers, panels and into drawers

LION ¼ TURN FASTENERS

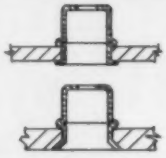
Quick, positive locking, by fractional turn. Tight seal formed by compression of leaf spring. Alignment and stack height not critical. Approved for aircraft use. Rugged. Extra strength provided by swaged nose. Vibration resistant.

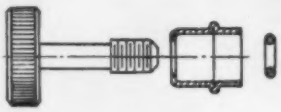




RETRACTABLE SCREW FASTENERS

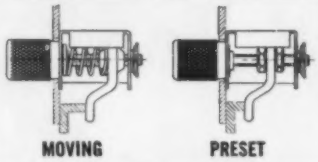
Stand-off thumb screws from stock to eliminate costly, special fasteners. Installed quickly without special tools. Accommodate misalignment. Complete range of standard sizes.

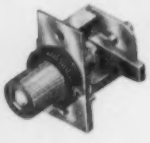




ADJUSTABLE PAWL FASTENERS

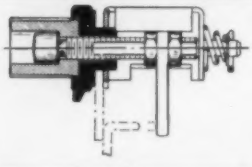
Pre-assembled, quickly installed. Accommodate variations in frame thickness up to ½ inch. One-quarter turn closes, additional turns increase grip pressure. Attractive appearance, long life. Moving or pre-set pawl. Miniature, intermediate and large sizes.





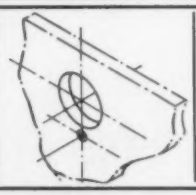
ADJUSTABLE PAWL FASTENER

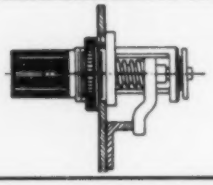
Has twin-knob control. One knob controls pawl, pointer shows pawl position. Other knob controls amount of pressure to seal closure with uniform pre-set compression. Easily installed.



ADJUSTABLE PAWL FASTENER

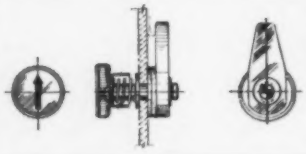
Compact and rugged. Eliminates rivets or bolts to save installation time. Three types cover grip range up to ¾". Supplied either with integral metal and plastic knob, plastic knob or for your knob.





ARROWHEAD DOOR LATCH

Requires only one hole to install. Operates on quarter turn. Holds under spring tension. Arrow shows pawl position; no pawl stops required. Uses minimum inside space.



Free Fastener Handbook

Send for your complete Southco Fastener Handbook, just printed. Write to Southco Division, South Chester Corporation, 236 Industrial Highway, Lester, Pa.

SOUTHCO FASTENERS
LION

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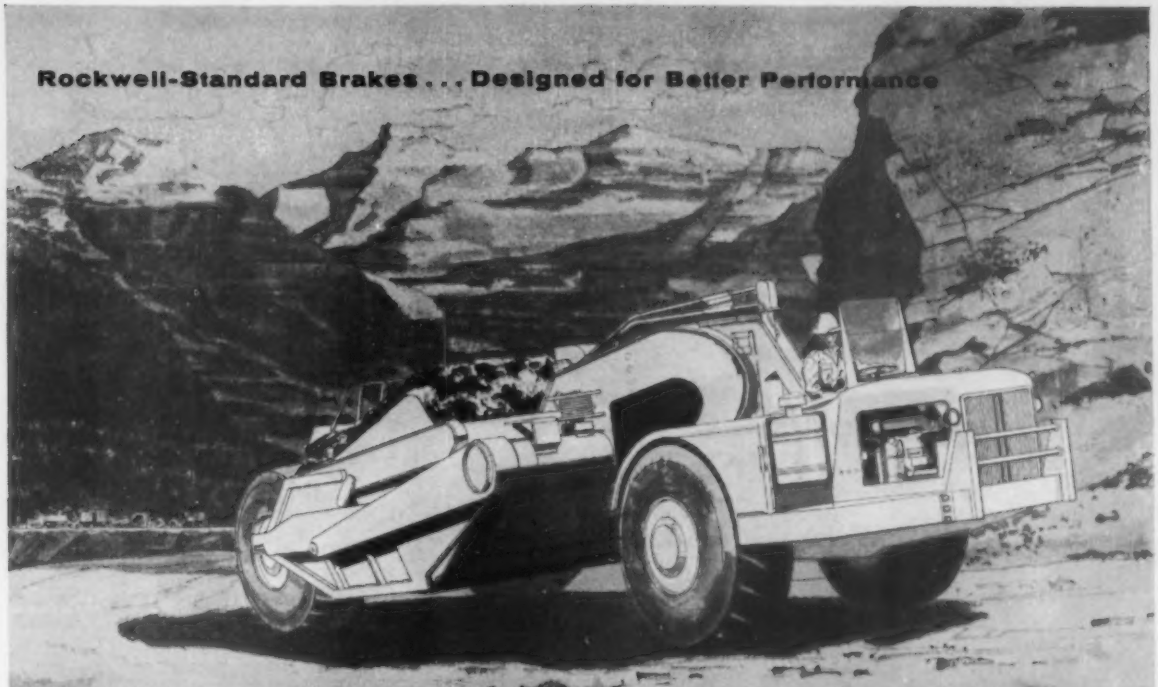

HEAVY-DUTY "P" SERIES POWER BRAKES

. . . real control for "heavyweight" power!

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Extra margin of safety. "P" Series Power Brakes make the largest construction vehicles as easy to control as a baby buggy . . . and they do it every time—more times—with complete dependability. Temperatures during operation are lower because of the open type spiders which assure good internal ventilation—rapid cooling.

Simple compact design. Heavy-duty "P" Series Power Brakes utilize a unit-mounted design—a compact, self-contained assembly. Camshaft and air chamber support brackets are mounted directly onto brake spider. (Inboard chamber mounting design is also available.)

Built-in long life. Rockwell-Standard ¾" "Econo-liners" are tapered to provide greatest thickness where most wear occurs . . . less waste material at reline. Other features include: heat-treated malleable iron brake shoes . . . securely riveted brake linings . . . constant lift S-type, heat treated cam . . . sealed, needle bearing camshaft mountings . . . long-life bronze bushings in anchor-pin holes . . . hardened, rust-proofed anchor pins.

You name it, we've got it. Complete range of capacities and sizes to fit every Heavy-Duty operating requirement.

Another Product of . . .

ROCKWELL-STANDARD
CORPORATION

ROCKWELL R STANDARD ®

Brake Division, Ashtabula, Ohio

FOR EVERY INDUSTRIAL, AGRICULTURAL OR AUTOMOTIVE APPLICATION WHERE BRAKING IS REQUIRED

Can These

FELT

BY FELTERS

IDEAS

Help You?

FELT GREATLY REDUCES GLAZING COSTS

over conventional brushing. Fine china manufacturer uses special Felters DuFelt Polishing Belt to reduce glazing costs. Felt coarseness and density can be varied for most effective polishing of metal, glass and ceramics. Can also be coated with abrasives.

FELT ADHESIVE TAPES AND PADS

are the most inexpensive material for sealing, padding and cushioning. Felt strips seal out dust, dirt, wind, fumes, moisture, and eliminate squeaks and rattles.

FELT AS A LOW COST FRICTION MATERIAL

Used as a braking or friction device, sometimes combined as a seal or washer. High coefficient of friction and extra density provide foolproof clutching and tension action at low cost, like the Lever Puller shown at left.

To get the most out of Felt, send for the Felters Design Book — a complete digest on properties and applications. Write, today.

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Pioneer Producers of Felt and Synthetic Non-Woven Fabrics 11-9-16

coated fabrics for industrial uses, their characteristics and recommended applications. E I duPont de Nemours & Co Inc, Fabrics Div, Fairfield, Conn.

Circle 370 on Reader Service Card

INJECTION MOLDED PLASTIC PARTS—Bulletin 1001, 8 pp. Presents properties of acetal resin and outlines established and potential uses. Gries Reproducer Corp, 400 Beechwood Ave, New Rochelle, NY.

Circle 371 on Reader Service Card

TAPE-WOUND CORES—Bulletin TB-105, 8 pp. Describes and illustrates new core materials and limits to which tape wound cores can be made. Core design data and case sizes are included. G-L Electronics, 2921 Admiral Wilson Blvd, Camden 5, NJ.

Circle 372 on Reader Service Card

SPECIAL ANALYSIS TUBING—Memo 121, 6 pp. General information, applications, and properties of columbium, tantalum and vanadium small tubing. Superior Tube Co, 1556 Germantown Ave, Norristown, Penna.

Circle 373 on Reader Service Card

PRECISION BALLS—Bulletin BU-1, 8 pp. Discusses raw ball materials, methods of manufacture, precision, finish, sizes and quantities. Industrial Tectonics Inc, PO Box 606, Ann Arbor, Mich.

Circle 374 on Reader Service Card

NON-WOVEN MATERIAL—Brochure, 8 pp. Tells what synthetic non-woven material is, how it is made and gives performance and application information. Troy Blanket Mills, 200 Madison Ave, New York 16.

Circle 375 on Reader Service Card

RIBBON FILTER ELEMENTS—Brochure 44, 4 pp. Applications and characteristics of series 2200 fluid filter elements. Illustrated with photos, drawings, curves and tables. Bendix Aviation Corp, 434 W 12 Mile Rd, Madison Heights, Mich.

Circle 376 on Reader Service Card

VALVES AND CYLINDERS—Bulletin SW-3, 8 pp. Construction features, sizes and ratings of air and hydraulic cylinders and valves. Galland-Henning Nopak Div, 2732 S 31st St, Milwaukee 46.

Circle 377 on Reader Service Card

MEASURING AND CONTROLLING SMALL FLUID FLOWS—Bulletin 18P, 4 pp. Describes line of instruments for measuring and controlling at low rates. Exploded drawing shows components and design. Sectional and dimensional draw-

(Continued on page 136)

ASCO Close-Differential Relays provide dependable, low-cost protection from under and over voltage.

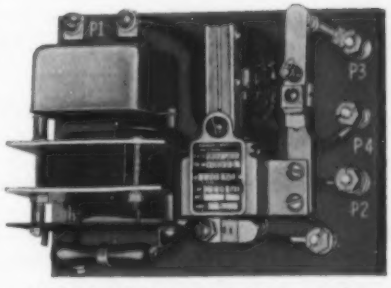
When a motor runs on low voltage for an extended period of time, burnout and fire may result. This can be costly in both down-time and damage to equipment.

You can protect your motors with ASCO Close-Differential Relays. They offer economical, dependable protection even when motor feedback conditions prevent ordinary potential relays from detecting changes in voltage. ASCO Close-Differential Relays respond to a 2% variation in voltage; protect motors when low voltage or over voltage conditions occur.

Because they combine sensitivity with rugged construction, ASCO Relays are providing low-cost protection in a wide variety of applications.

For example, in some oil burner installations, ASCO Relays help prevent explosions due to under voltage. In these installations, when under voltage occurs, ASCO Relays prevent oil build-up in the pit by detecting this low voltage condition, and causing oil flow to be cut off immediately. Otherwise on under voltage the oil would build-up in the pit since the ignition system would not fire. This excess oil could result in an explosion when voltage is restored and the ignition system fires.

Find out how the ASCO Close-Differential Relay can protect your equipment. Send for Catalog 57-S4 describing the complete line of ASCO Relays.



ASCO Close-Differential A-C Relay operates on 2% variation in voltage—features positive action, quiet operation, power relay type contacts.

Dependable control by ASCO is available from representatives and distributors in all principal cities.

Automatic Switch Co.

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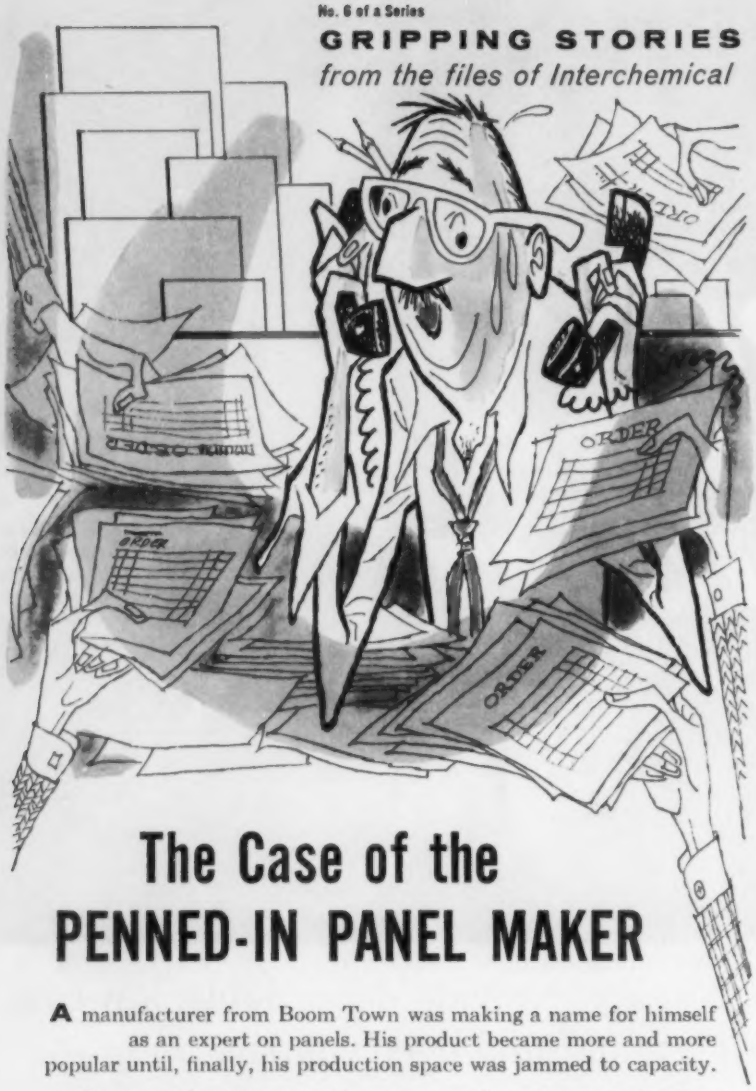
AUTOMATIC TRANSFER SWITCHES • SOLENOID VALVES • ELECTROMAGNETIC CONTROL

ASCO®

No. 6 of a Series

GRIPPING STORIES

from the files of Interchemical



The Case of the PENNED-IN PANEL MAKER

A manufacturer from Boom Town was making a name for himself as an expert on panels. His product became more and more popular until, finally, his production space was jammed to capacity.

On examining the production set-up, an Interchemical adhesives engineer quickly saw that the bottleneck was caused by the need to spray *both* the hardboard backing and plastic facing with adhesive before lamination.

"Let's see if Interchemical can come up with a one-coat adhesive that will eliminate half of your spraying requirement," he said. Interchemical could and did. And our penned-in panel maker was able to double his output without expanding his space. Interchemical's broad experience in supplying lacquers, coatings and adhesives for many industries is an important practical advantage wherever problems arise. For efficient, economical *job-formulated* adhesives — see your local Interchemical adhesive man.

Call or write today *for complete information.*

ANGIER ADHESIVES

INTERCHEMICAL CORPORATION
Finishes Division
120 Potter St., Cambridge 42, Mass.
Midwestern Plant: HUNTINGTON, IND.

Catalogs and Bulletins.....continued

ings, capacity information and diagrams of typical uses are included. Schutte & Koerting Co, Dept M-P, Cornwells Heights, Bucks County, Penna.

Circle 378 on Reader Service Card

DACRON IN V-BELTS—Brochure, 6 pp. Performance information and curves on V-belts reinforced with Dacron. E I duPont de Nemours & Co, Wilmington 98, Del.

Circle 379 on Reader Service Card

MECHANICAL DRIVE—Bulletin 3600, 6 pp. Gives specifications and application information on mechanical adjustable speed drive with speed ranges up to 8:1, in ratings from 1 to 30 hp. Louis Allis Co, Milwaukee 1.

Circle 380 on Reader Service Card

CERAMIC CAPACITOR—Catalog sheet 1959-2, 2 pp. Environmental characteristics, performance information and ratings of units with capacity values to 10,000 mmf. Vitramon Inc, PO Box 544, Bridgeport 1, Conn.

Circle 381 on Reader Service Card

PERMANENT MAGNETS – Engineering bulletin 350, 2 pp. Describes magnetic and material characteristics of Hyflux Alnico V-7, as well as applications. Indiana Steel Products Co, Valparaiso, Ind.

Circle 382 on Reader Service Card

POSITION INDICATOR—Catalog sheet, 2 pp. Specifications and dimensions of series 2600 drum-type latitude and longitude counters. Chicago Dynamic Industries Ind, Precision Products Div, 1725 Diversey Blvd, Chicago 14.

Circle 383 on Reader Service Card

(Continued on page 140)

"Confound it! I wish you would stop coming in here every time you find some little fault with the flight characteristics!"

6 SIX WAYS TO DESIGN FOR operator comfort

Protecting the operator from the discomfort and fatigue of vibration/shock/noise has become a vital consideration in modern equipment design.

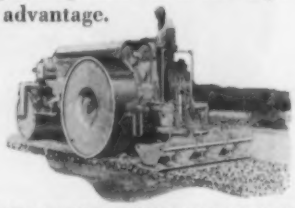
Exposure to the subtle effects of vibratory disturbances can affect operator equilibrium, cause motion sickness or impair efficiency, morale and mental attitude. These in turn can lead to lower output, complaints, equipment misuse and accidents.

Check the ideas presented here for ways of upgrading the operator comfort of your product. The result could be an important competitive advantage.

1 REDUCE SHOCK AT HANDLE

Shock absorbing handle on pneumatic rock drill eliminates 55% of tool shock without loss of impact at bit. Lord Dynaflex Joint in handle linkage is flexible torsion member which reduces operator fatigue. Result: higher daily output.

2 PROTECT FROM VIBRATORY DISTURBANCES



Vibratory compactor on road roller produces 4200 three-ton jolts per minute which can turn operators' legs to "jelly". Lord mountings applied at vibrator shoes isolate 98% of vibration, protect operator and machine components from fatigue.

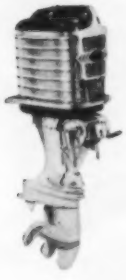
3 INSURE SMOOTH RIDE

Lord Dynaflex Joints, incorporated in front wheel fork, eliminate "bounce" and provide excellent riding and steering characteristics. Golf car manufacturer reports that elastomeric spring is "most durable shock absorbent unit available."

4 ISOLATE ENGINE VIBRATION

Garden tractor with single-cylinder engine base-mounted on flexible suspension enjoys competitive advantage of relaxed, vibrationless ride. Lord Plate Form Mountings isolate firing and torque disturbances, provide stability against drive belt pull.

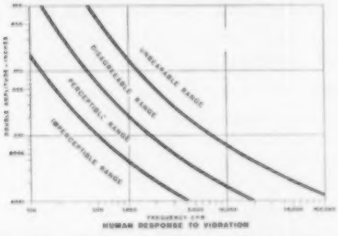
5 ASSURE QUIET OPERATION



Lord Dynaflex Mountings on outboard engines reduce structure-borne noise, isolate engine and propeller vibrations, absorb power impulses and inertia forces. Elastomeric units contribute to "soft sound" and greater passenger comfort.

6 USE THIS HELPFUL DATA

This Human Response to Vibration Curve will guide you in designing your equipment for greater operator comfort. And for authoritative assistance in vibration/shock/noise control, rely on the unmatched experience of Lord engineers.



HUMAN RESPONSE TO VIBRATION

Contact the nearest Lord Field Engineering Office or the Home Office, Erie, Pa.

FIELD ENGINEERING OFFICES

ATLANTA, GEORGIA · CEdar 7-9247
BOSTON, MASS. · HAncock 6-9135
CHICAGO, ILL. · MIchigan 2-6010
DALLAS, TEXAS · Riverside 1-3392
DAYTON, OHIO · BAldwin 4-0351
DETROIT, MICH. · Diamond 1-4340
KANSAS CITY, MO. · WEstport 1-0138
LOS ANGELES, CAL. · HOllywood 4-7593
NEW YORK, N. Y. · Circle 7-3326
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Located everywhere from coast to coast, Ford Power Dealers offer prompt parts delivery and immediate on-the-job service to help you keep costly downtime at a minimum. Because each dealer carries a stock of normal replacement parts, you need never invest in a large parts inventory of your own. What's more, you get these parts at low cost because of Ford's modern production and distribution methods.

If you need a complete engine or power unit installation, check Ford's full line of dependable engines. These engines range from 134 to 534 cubic inches—including Ford's 220- and 330-cubic inch Diesels. And for really big jobs, there are three Super Heavy Duty V-8's—now available with 5- and 8-speed transmissions and the new 6-speed automatic transmission.

To get the *right* engine for your application—with readily available service that will help keep your operating costs down—select a Ford Industrial Engine.

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PRECISION SEALS

engineered to your product

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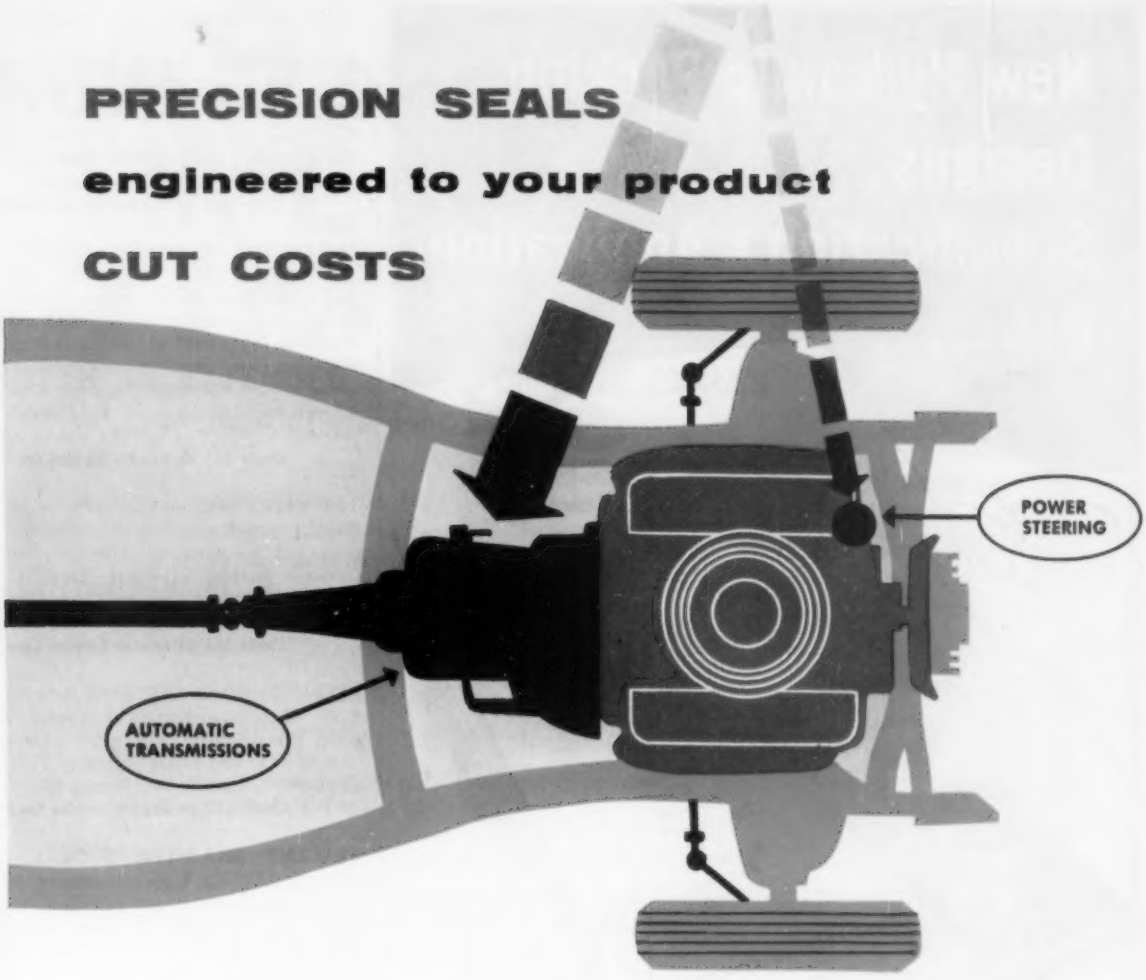

Problem Solving is a common occurence at Precision. One was the development of a universal compound for automatic transmissions and power steering systems. **The Solution**—Precision Compound No. 6767—provided an "O" Ring with these characteristics. Suitable for all transmission fluids . . . particularly type "A" . . . long life over a temperature range of —40F to 300F . . . excellent resistance to cracking . . . low volume change . . . low compression set . . . high modulus. Precision creative research has reduced costs by producing the right "O" Ring for many manufacturers. You can benefit too, for the services of a Precision engineer are available to help you obtain the right product design and the right "O" Ring for it. Write or phone for his services today.

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"O" Ring and Dyna-seal Specialists

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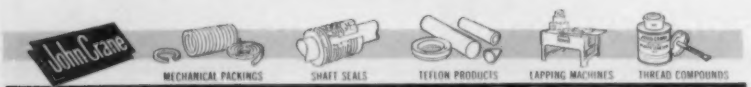
New Hydraulic Packing Designs . . . . . Specification & Application Data . . . .

Here is complete information on the finest available line of hydraulic packings . . . an extremely wide variety of types and constructions, each correctly compounded to particular service requirements and laboratory controlled to insure uniform quality. Available now from "John Crane", this complete line is the answer to practically every hydraulic packing requirement.

Request Catalog 90. You can't afford to be without this detailed engineering guide.

Crane Packing Co., 6445 Oakton Street, Morton Grove, Illinois *(Chicago Suburb). In Canada: Crane Packing Company, Ltd., Hamilton, Ont.*



Catalogs and Bulletins . . . . . continued

TWO-CIRCUIT SWITCHES – Data sheet 164, 2 pp. Photos, mounting dimension drawing, characteristics and electrical data, list price and discounts for 3MN series of precision two-circuit switches. Micro Switch, Freeport, Ill.

Circle 384 on Reader Service Card

PROTECTING ELECTRICAL, ELECTRONIC EQUIPMENT–Folder, 4 pp. How inhibitor works to prevent moisture damage and corrosion on electrical and electronic equipment, advantages and applications, case histories and physical specifications. Corrosion Reaction Consultants Inc, 116 Chestnut St, Philadelphia 6.

Circle 385 on Reader Service Card

3-HP VIBRATOR–Bulletin 1016E, 4 pp. General information, construction features and specifications of vibrator for precision finishing of metal, plastic or wooden parts. Lord Chemical Corp, 2068 S Queen St, York, Penna.

Circle 386 on Reader Service Card

STEEL TUBING SYSTEMS–Bulletin, 4 pp. Discusses application of soldered or silver brazed tubing systems to replace screwed or welded piping. Standard Tube Co, 24400 Plymouth Rd, Detroit 39.

Circle 387 on Reader Service Card

BRACKET MOUNTED SOCKETS–Brochure LD-859, 4 pp. Assortment of sockets are illustrated and described, together with appropriate lamps for which units are designed. Leecraft Mfg Co Inc, 58 Greene St, New York 12.

Circle 388 on Reader Service Card

VERTICAL HOLLOW SHAFT MOTORS–Bulletin 212, 4 pp. Explains and

(Continued on page 144)

"Surprised to see you at work, Harry—thought you were supposed to start your vacation today."

NOW 9 STANDARD TYPE TIME DELAY TIMERS

IN AN EXTENDED RANGE OF TIME CYCLES

1/60th of a second to 24 hours

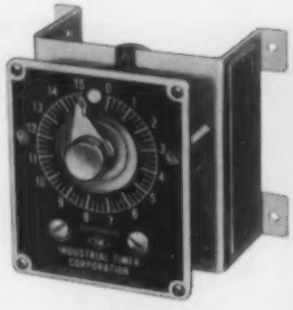
For bigger savings in OEM design and installation now, choose a standard time delay timer from Industrial Timer's expanding line to satisfy almost *every* mounting requirement... back, side, flush, through-the-panel, totally enclosed or explosion proof. Industrial Timer's bigger-than-ever selection gives you greater design latitude in both function and appearance... eliminates the need for costly custom-made controls in your specifications.

All 9 types have these special features:

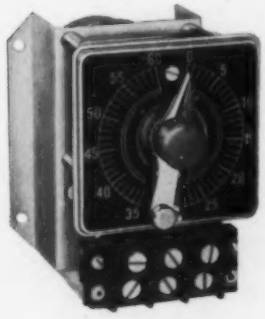
1. Actuated by momentary *or* sustained pulse
2. Automatic reset
3. Heavy duty load switches rated at 10 and 15 amps
4. Easy, positive adjustment of time cycles

By specifying Industrial Timer you are assured of accurate and dependable controls for applications requiring a specific time delay between circuit operations. Full details in Bulletins 300, 800 and 900.

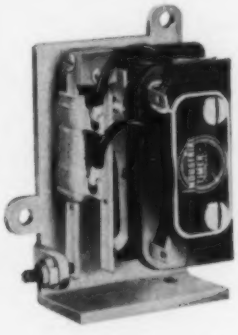
Series 90
Back-mounted, for applications where time cycle is infrequently changed or permanently fixed (½ sec. to 5 min.)



Series SF
Back-mounted (1/10 sec. to 5 min.)



Series TDAB
Flush-, back-mounted or totally enclosed (1/60 sec. to 3 hrs.)



Series TH
Back or bottom-mounted. Thermal time delay switch. (15 sec. to 2 min.)

Series TDXP
Bottom or back-mounted. Explosion proof. External adjustments (1/60 sec. to 3 hrs.)

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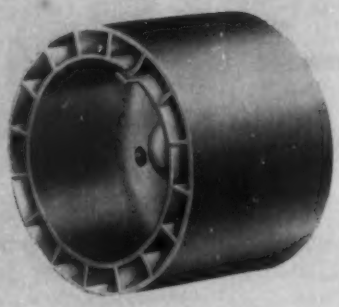

magnesium

cobalt alloy

stainless steel

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illustrates construction and design of motors from 15 to 125 hp. Includes cutaway illustration and specifications. Ideal Electric and Mfg Co, Mansfield 85, Ohio.

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Letterhead Requests Only

Manufacturers who published following literature asked that requests for copies be made on company letterheads.

MOTOR CONTROL—Vol 1, 162 pp. Covers control components, with application information, general descriptions, ratings, sizes and list prices. Includes dimensional drawings and illustrations. Allis-Chalmers Mfg Co, Milwaukee 1.

ALUMINUM FORGING—Book, 336 pp. Various types of forging processes and advantages of using aluminum forgings are presented. Glossary of terms common to aluminum forgings is also indexed. Copies are free when requested on letterhead; personal library copies are $7.50 each. Kaiser Aluminum & Chemical Sales Inc, 1924 Broadway, Oakland 12, Calif.

MECHANICAL RUBBER PRODUCTS—Handbook M-60, 68 pp. Contains base polymer charts giving resistances of vulcanates and recommendations for use under specific conditions, as well as a compound identification system. Actual swatches are included and 18 standard colors are shown. Typical custom molded products are illustrated and over 500 standard parts are drawn to scale. Lavelle Rubber Co, 424 N Wood St, Chicago 22.

SCREW MACHINE MANUFACTURERS—Buying directory, 1959-60 edition, 80 pp. More than 270 member companies are listed alphabetically and geographically for ease of reference. Covers location and facilities available. National Screw Machine Products Assoc, NSMPA Bldg, 2860 E 130th St, Cleveland 20.

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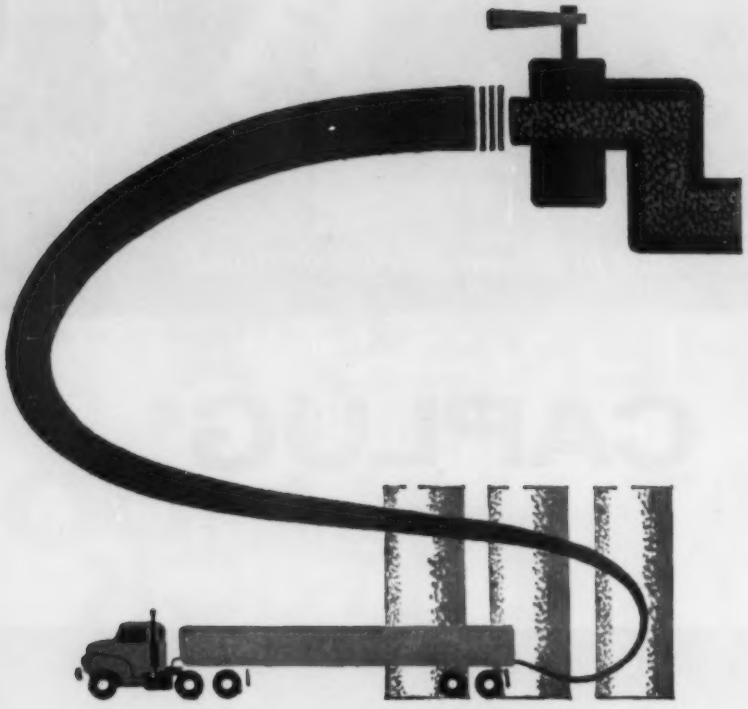
Do it with help from Product Engineering's recent series, "Eight Steps to Better Engineering Writing." All eight articles have been combined into a free reprint that is now available. Orders are piling in, but you can still get your own copy. It's a down-to-earth guide showing how to make your ideas concise, simple, clear . . . how to write more powerful memos, letters, reports, proposals. For a copy, just Circle P15 on the Reader Service Card.

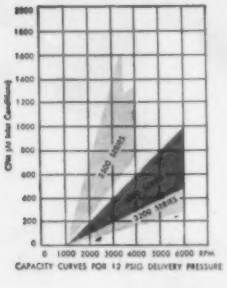


NEW M-D GEARED P.T.O. BLOWERS . . . NO BELTS-NO PULLEYS

for tractor mounted conveyor systems

Now a compact, 3-lobe M-D blower fits *inside* tractor frame . . . weighs only 165 lbs. Geared-in-head blower (2 to 1 or 2½ to 1 ratios) connects directly to truck P.T.O.—no belts or pulleys—develops 15 PSIG continuous air flow or up to 18 PSIG in surges.

M-D blowers operate at wider pressure and speed ranges than any other rotary positive blower. Capacities of 22 production models range from 50 to 4,000 CFM, pressures to 15 PSIG single, 70 PSIG multi-stage.



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M-D BLOWERS, INC.

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NEW WEATHERHEAD

TEF-SEAL NUT

makes every pipe connection LEAKPROOF!

***SAVE** - expensive maintenance costs*
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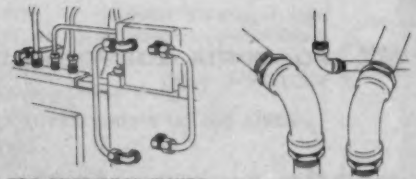


FOR HYDRAULIC FLUIDS

FOR ALL PROCESSING INDUSTRIES

FOR WATER

Eliminates leaks on all pipe threads—Dry Seal or standard. No pipe compound required. Quick, easy installations in cramped quarters where wrench clearance is limited.

Tef-Seal Nuts are an economical substitute for straight thread "O" ring boss fittings using original female pipe ports. Tef-Seal gives you positive seal on directional fittings like tees and elbows without distorting mounting bosses or damaging expensive valves and pumps.

NEW FORGED STEEL PIPE FITTINGS

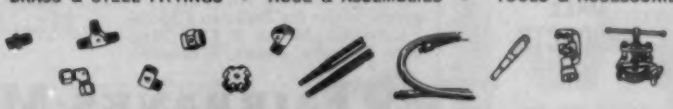
Available in a wide range of sizes and styles, to meet most piping requirements.

Weatherhead steel pipe fittings are rugged, dependable for high pressure applications. They are precision machined from AISI 12L14 material to meet GMC dimensional standards. Weatherhead's exclusive ball-drilling process leaves no edges or sharp corners, eliminates turbulance and insures smooth, full flow. Corrosive resistant Weathercote finish is standard on these fittings, permits their use with all types of hydraulic fluids, water and air.

SPECIFICATIONS

Pressure Rated at 3,000 p.s.i. working pressure
Proof Tested: 15,000 p.s.i. in sizes up to 1¼"
10,000 p.s.i. in sizes 1½" and up
Each fitting is marked with its individual rating
All threads are American Standard Taper Pipe Threads — Dryseal (N.P.T.F.)

BRASS & STEEL FITTINGS • HOSE & ASSEMBLIES • TOOLS & ACCESSORIES



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Frame HMD

Frame HM

Frame HMB

Priced competitively with any similar U. S. or foreign motor.

• Sub-Fractional • Lowest Cost • No Vibration • Synchronous

The new DALOHM hysteresis motor provides all the desirable characteristics of such motors, yet doesn't have the usual heat rise handicaps. Small and light-weight, its new pancake configuration is space saving.

Low cost is achieved by advanced design and production techniques. It is more economical to use because it uses a smaller capacitor than comparable motors.

Ideally suited for facsimile machines, Hi-Fi turntables, tape recorders, tele-metering and many other types of equipment where constant synchronous speed is essential.

- Low noise
- Maintains synchronous speed at rated load
- No vibrations or magnetic strays
- Reaches full RPM in one revolution
- Exceptionally low cost
- Will start at voltages as low as 100 volts, and will operate from 100-120 volts

RUNNING TORQUE: 1.9 in./oz. to 28 in./oz.

VOLTAGE: 115 V., 60 c.p.s.

SPEED: 1800 RPM (variable with frequency)

HORSEPOWER: 1/20th to 1/300th

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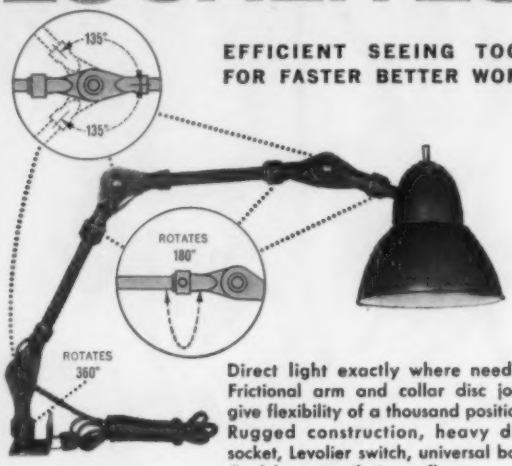

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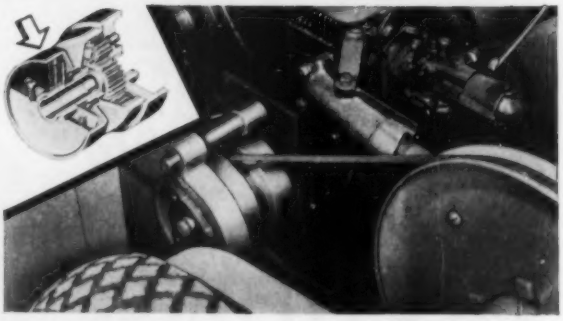
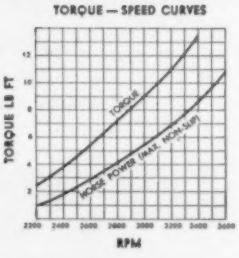
CIRCLE 205 ON READER SERVICE CARD

Automatic transmission has integral drive sheave



Now, get a centrifugal clutch, integral sheave, and planetary reverse gearing in one low-cost, easy-to-install package. It's compact, only 3-7/8" x 4-5/16" — available for 1-1/2 to 5-hp engines. Clutch engages at best engine speed, has high torque capacity (see graph). Hand brake stops rotation and sun gear reverses sheave through spur gears. Write for Bulletin FM 296. Fairbanks, Morse & Co., Magneto Division, Beloit, Wisconsin.



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CIRCLE 146 ON READER SERVICE CARD

CIRCLE 206 ON READER SERVICE CARD

Current Reprints

Selected articles in recent issues have been reprinted in convenient form for filing. As long as the supply lasts, readers in US and Canada can secure one copy of any of these reprints without charge, by using one of the Reader Service Cards bound inside the back cover. Note that the card must be used within 60 days of publication date. If more than one copy is needed, see price list.

Reinforced Plastic Springs
Leaf springs from epoxy laminates can outperform steel. Nov 9 **Circle P 20**

Latest Trend in Bolt Threads
Root radius is getting larger—75% threads now; 55% threads a possibility. Nov 9 **Circle P 19**

18 Ways to Control Gear Backlash
This roundup includes latest devices for answering a chronic problem. Oct 26 **Circle P 18**

Pressure Drops in Pneumatic Systems
New method predicts losses when components are in series. Oct 26 **Circle P 17**

Yardsticks for Research Success
Equations and procedures used to gage the future of a product. Oct 19 **Circle P 16**

8 Steps to Better Engineering Writing
This eight-page report appeared in serial form from Sept 7 to Oct 26 **Circle P 15**

3 Steps to a Battery-powered Motor
Electric auto is example—how to choose the best motor for the load. Oct 12 **Circle P 14**

Closer Look at Cast Iron
For predicting service performance, look at the microstructures. Oct 12 **Cirle P 13**

Planetary Drive Run by Rollers
Replacing gear drive cuts noise and vibration in fast planetary system. Oct 12. **Circle P 12**

Molding with Polyester Premixes
A different design approach is necessary with these reinforced plastics. Oct 12 **Circle P 11**

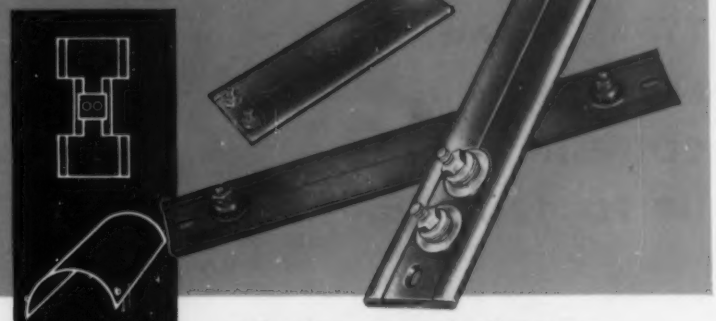
Ballbearing Tests
Combined reprint: test methods for torque, vibration and runout. Sept. 14; devices to check preload and play. Sept. 28 **Circle P 10**

Specifying Anodized Aluminum Finishes
Practical guide to ways that will give the specific coating needed. Sept. 28 **Circle P 9**

(Continued on page 151)

WATLOW

STRIP HEATERS



all sizes and shapes... for all kinds of electric heat installations

LONG-LIFE CONSTRUCTION. Durable nickel-chromium wire is completely enclosed in mica and permanently located within the sheath, which is literally stretched "like a skin" around the compact resistor assembly.

THIN, LIGHT AND EFFICIENT. Space-saving design plus the extremely high dielectric strength of the mica, makes thinner cross-section of insulation. The resulting strip heater is extra thin, lightweight, responds quickly to control, operates at maximum efficiency with minimum time lag or burnout.

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WATLOW
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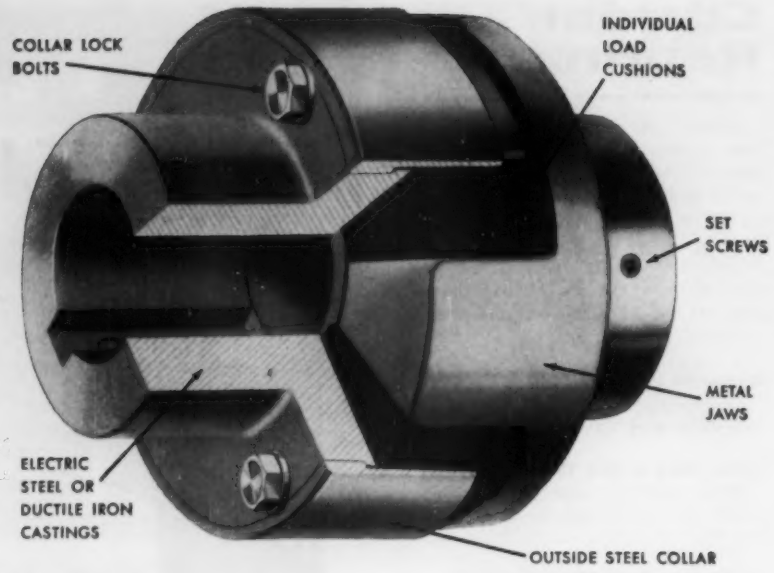
CIRCLE 147 ON READER SERVICE CARD

A Report To Equipment Manufacturers

LOVEJOY TYPES C and H FLEXIBLE COUPLINGS UP TO 4250 hp.



Installed and Aligned In Minutes

Just slide on the shaft, bring the jaws together and insert cushions. A twist of the bolts on the outside collar firmly retains the visible cushions.

Alignment is equally simple. Just use a straight edge. Gauges are not required.

Eliminate Trouble and Service Calls

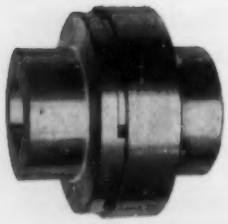
Lovejoy Flexible Couplings contain no intricate parts or mechanisms that require attention or can cause possible trouble. All parts, including cushions, are in plain sight for rapid inspection. Lubrication is never required. Water, oil, dirt or weather will not harm or in any way decrease efficiency.

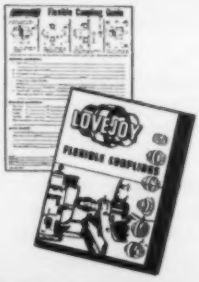
The best care for Lovejoy Couplings is to *put 'em on shafts and let 'em alone.*

Outlast Equipment Life

Bodies are carefully machined from electric steel or ductile iron castings. The load is entirely transmitted by cushion compression, eliminating metal-to-metal contact and resultant wear on metal parts and jaws.

Even the cushions last longer. First, they are furnished in the material best suited to the service. Second, on non-reversing loads, their life can be doubled simply by reversing or advancing.





Lovejoy Flexible Couplings can be delivered immediately from stock. Heavy-Duty Types C and H run from 18 to 4250 hp. at 1200 rpm. in a wide range of bore sizes. Other sizes and types run from .05 at 100 rpm. to 1020 hp. at 1600 rpm. to provide the most complete selection of couplings available to industry.

Request full information and ask for Catalog C-58. Give details or specifications for prompt quotation.

Lovejoy

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SERIES 101A

AIR 150 PSI • HYDRAULIC UP TO 1500 PSI • MEETS JIC STANDARDS

By fitting into one-third less space than a tie-rod cylinder of the same bore, this original O-M space-saving component gives greater flexibility to design, reduces weight and cuts installation time.

But there are many other reasons for using this O-M Round-line Cylinder that delivers smooth, dependable power. It has the lowest coefficient of friction . . . assures full-power starts . . . is sealed right—ports are easily oriented independently to 360 degrees...and, end plugs are tapped for universal mounting. Easily modified for special applications at a nominal extra over standard cylinder prices. Internal locking key makes it easy to disassemble, service and reassemble with no alignment problems.

Available for Air or Hydraulic circuits in a complete range of sizes (1½" to 8" bores) with standard, 2 to 1 or oversize rods. All-steel construction with bearing bronze. Completely interchangeable parts. Immediate delivery on many sizes.

Mail coupon at once for Bulletin 101A containing engineering drawings of cylinder, mounts, mounting brackets, capacity chart and other data.

ORTMAN-MILLER MACHINE CO.
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CIRCLE 149 ON READER SERVICE CARD 149

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Your best solution is . . .

AIR
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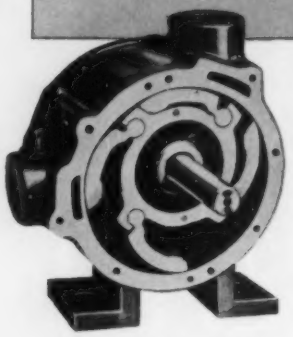
—and your most efficient air source is

LEIMAN Rotary Positive AIR PUMPS



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Leiman Air Pumps, with exclusive hinged vane design, have 2 to 3 times greater air space per size and weight of pump . . . provide higher vacuum, suction or pressure with smaller pumps, slower speeds. Fewer moving parts, and all parts made of durable cast iron and steel (no composition). Take up their own wear to provide "lifetime" dependability. Quiet running. Every pump tested before shipment. Over 70 years' air engineering at your service on any design or problem.

VACUUM to 29.9″ Hg.
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Silicone Sponge Rubber

flexible at temperatures —100°F to 500°F

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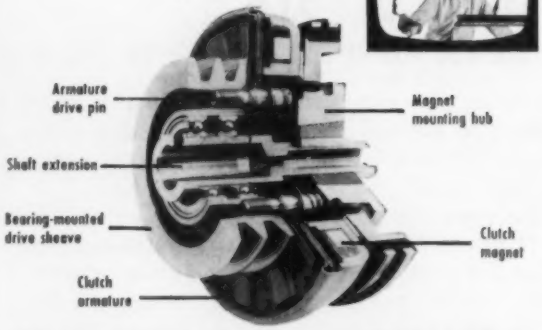
Main Office: New Haven 9, Connecticut

new . . . electric clutch-pulley package



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Modernizes machine drives and controls—fits all standard NEMA motors. Direct, low-cost method of converting to fully automatic or remote control. Fastest way to cycle a machine drive, with motor running continuously. Operates at any speed. Reduces motor wear and power consumption. Smooth, *adjustable* acceleration. Simple to install. Five sizes, from 1 to 25 hp, available off-the-shelf from all Warner distributors. Write for Bulletin P-52.

WARNER

Warner Electric Brake & Clutch Co.
Beloit, Wisconsin

CIRCLE 208 ON READER SERVICE CARD

CIRCLE 150 ON READER SERVICE CARD

AUTOMATIC ASSEMBLY

IS FAST,

ECONOMICAL,

TROUBLE-FREE

with Milford tubular rivets and automatic riveters

Mass production and automatic assembly cut costs only when all operations are trouble-free. That's why the high strength and uniform quality of Milford Tubular Rivets, plus Milford's wide line of precision riveters, are playing an active role in slashing today's production costs.

For the answers to assembly problems... *get in touch with Milford first!*

THE MILFORD RIVET & MACHINE CO.

MILFORD, CONNECTICUT • HATBORO, PENNA.
ELYRIA, OHIO • AURORA, ILL. • NORWALK, CALIF.

CIRCLE 209 ON READER SERVICE CARD

Current Reprints .....continued

13 Ways to Cut Drafting Costs
List of helpful modern methods, materials and equipment that save money. Sept. 28 Circle P 8

Fixed Resistors
Three-step method chooses type and rating for power and control. Sept. 28 Circle P 7

More Engineering per Engineer
Review of new techniques designed to reduce the noncreative load on engineers. Sept 21 Circle P 6

Equipment Says it in Color
How eye-catching color code conveys information from machine to operator. Sept 14 Circle P 5

New Data for High-Pressure Air
Properties of air under pressure. Curves useful from 0 to 12000 psi and —150 to 250 F. Sept 14 Circle P 4

Latest in Slip Clutches
Describes two new designs, one of them a dual-spring type. Aug 31 Circle P 3

What Is Creativity?
Latest methods for measuring, controlling and stimulating creativity in R&D. Aug 24 Circle P 2

Porcelainized Cast Aluminum
How low-temperature fits may be applied to permanent-mold castings and sheet aluminum. Aug 17 Circle P 1

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For single shipments of any one title to one address on order accompanied by remittance, quantity orders will be supplied at the following prices as long as the supply lasts.

Quantity	Price per Copy
5	$0.25
25	0.20
50	0.15
100	Write for quotation

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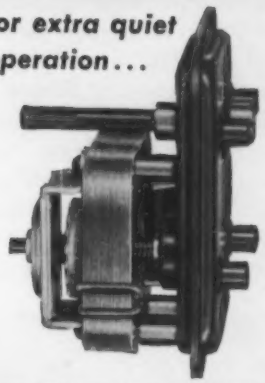
"No, Mr. Smith is not in conference, he's busy."

GENERAL INDUSTRIES

Smooth Power

AC MOTORS

for extra quiet operation...



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with gear reductions

Designed for low-speed, high-torque applications, GI Gear Motors are widely used in TV Remote Control Units, Vending Machines, Timing Devices, etc. Molded nylon gears in a dirt-sealed housing insure extremely quiet running plus rugged dependability. Rotor disengages, if required, when gear train is de-energized. For reliability, plus extra silent service, specify GI Gear Motors. Precision-made, with mass-production economy.

GENERAL SPECIFICATIONS

MODEL 205		
	Intermittent	Continuous
SPEED	13 RPM	13 RPM
TORQUE	150 in./oz.	100 in./oz.
AMPS, No Load	2.5	1.25
WATTS, No Load	26	13
REVERSIBLE	No	No
CONDENSER	None	None
MODEL 308		
	Intermittent	Continuous
SPEED	13 RPM	13 RPM
TORQUE	150 in./oz.	90 in./oz.
AMPS, No Load	1.2	0.6
WATTS, No Load	24	12
REVERSIBLE	Yes	Yes
CONDENSER	60 MFD	60 MFD

Above data based on 24 volts—Intermittent Duty 3 minutes on and 5 off. Both models can also be supplied for 115 volts — 60 cycles.

Write for Catalog and Quantity Price Quotations

THE GENERAL INDUSTRIES CO.

DEPARTMENT GK • ELYRIA, OHIO

CIRCLE 151 ON READER SERVICE CARD

WHEN YOU WANT TO TOUCH THE UNTOUCHABLE

You may design manipulators for radioactive materials . . . control devices for corrosive chemicals . . . laboratory equipment for research on deadly viruses. *Whatever* you design, if it calls for precision instrument ball bearings, Fafnir can help you. Low torque, for example, is insured through Fafnir's balanced bearing and retainer design, extreme accuracy in geometry of parts, superior finishes, and "clean room" assembly. Let Fafnir's uniformly high standards of quality plus diversity of types, sizes, and materials help *you* "touch the untouchable" in meeting exacting requirements. The Fafnir Bearing Company, New Britain, Connecticut.

Fafnir precision instrument ball bearings are available in four tolerance classes—ABEC 1, 3, 7, and Modified 7—to meet specific needs.

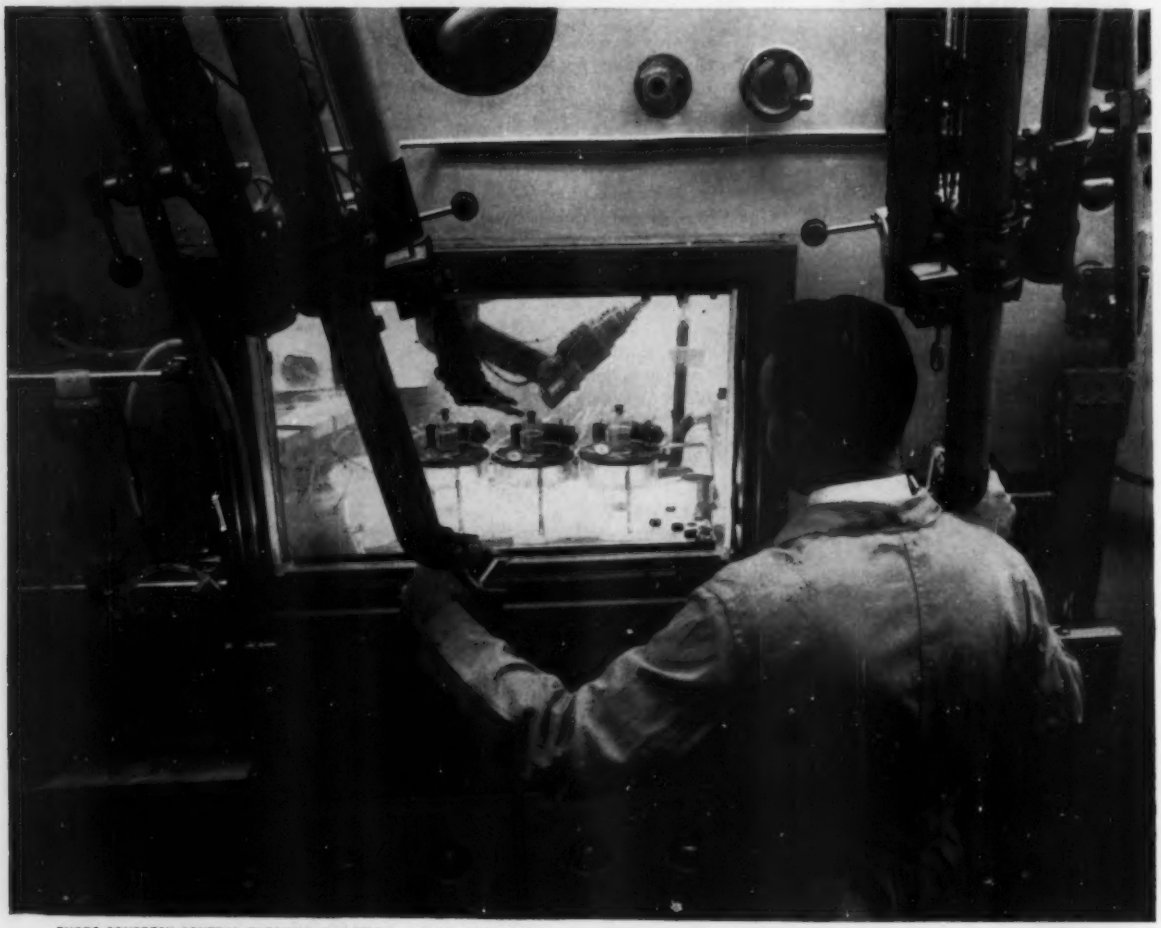
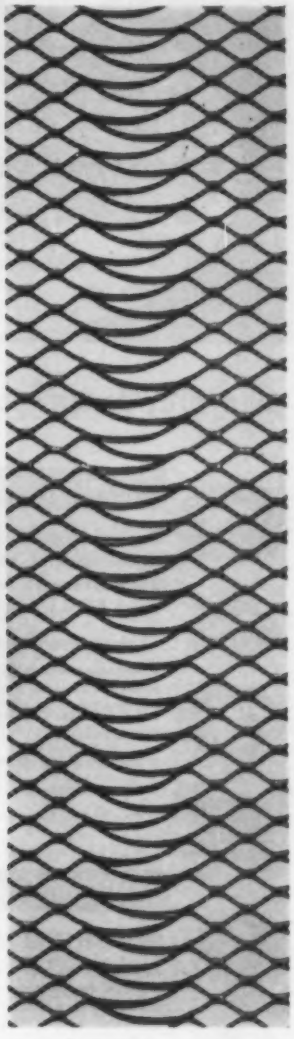


PHOTO COURTESY GENERAL ELECTRIC VALLECITOS ATOMIC LABORATORY

FAFNIR
BALL BEARINGS

Oasis Dehumidifier by Ebco Manufacturing Co., incorporates a grille of Penmetal Garland expanded aluminum, shown actual size below.



Fresh expanded-aluminum pattern accents restyled dehumidifier

Clean lines . . . a crisp, new look that will last . . . greater utility . . . these are some of the qualities gained by Ebco designers in re-styling the Oasis dehumidifier.

The rich, anodized grille of Penmetal expanded aluminum handsomely accents the mocha-tweed vinyl-covered cabinet. Penmetal's new Garland pattern has depth and variety . . . is a lasting invitation to the eye. The golden color is an integral part of the metal . . . for permanent brilliance. Expanded metal has high strength-to-weight ratio . . . comes in a number of exciting new patterns. For full details, send for illustrated folder 516-EM.

PENN METAL COMPANY, INC. 90th YEAR 1869 – 1959

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Plant: Parkersburg, W. Va.
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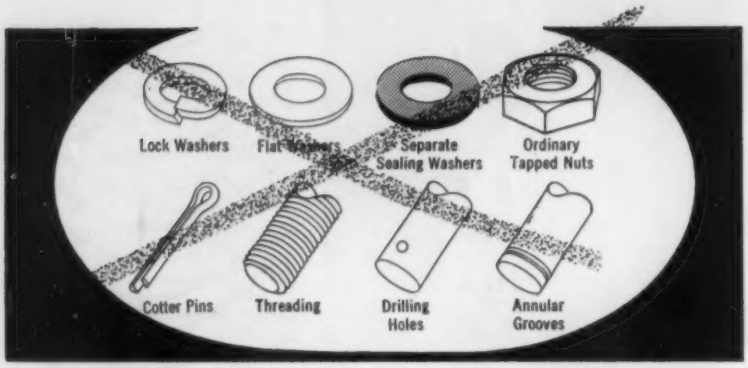
PM-216

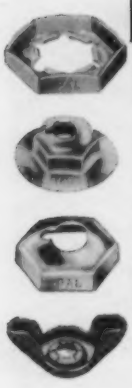
CIRCLE 153 ON READER SERVICE CARD 153

PALNUT® LOCK NUTS and FASTENERS *Eliminate*

one or more of these assembly parts or operations



–and provide compact, vibration-proof assemblies



PALNUT Lock Nuts for Threaded members

Spring tempered steel Palnuts, with the dependable double-locking thread form, are available in many stock types and sizes to meet practically any assembly need. Here are typical advantages:

- **Low cost**—less than other locking devices, often less than plain nuts.
- **Easy, fast assembly** with ordinary manual or power tools, extra fast with Palnut Magnetic Wrenches.
- **Save Parts.** One Palnut replaces 2, 3, even 4 parts according to application.
- **Save Space** by eliminating auxiliary parts.
- **Save Weight**—up to 85% reductions in fastener weight.
- **May be removed and re-used.**

FASTENERS for Unthreaded Studs, Rods, Pins, etc.

SELF-THREADING NUTS

Save threading costs. Form their own deep, clean threads while tightening on studs of any malleable material, including aluminum or zinc die-cast; also rods, shafts, wire or pins of steel, aluminum, brass or plastic. Fast assembly with standard tools. Vibration-proof grip, whether seated or unseated. Remove and reuse on same studs. Sizes for #8, #10, #12 and #1/4 dia. Write for Bulletin 585-A.

PUSHNUT® FASTENERS

Simply push on unthreaded studs, rod, wire or rivets. Strong spring grip resists removal. Save threading, grooving, drilling for cotter pins. Low in cost, fast assembly. Many types and sizes.

Write for Catalog 573-C and Free Samples, stating type, size and application.

THE PALNUT COMPANY, 65 Glen Road, Mountainside, N. J.
In Canada: P. L. Robertson Co., Ltd., Milton, Ont.

PALNUT® LOCK NUTS FASTENERS PAL®

Quick, secure fastening at low cost

Tangents...

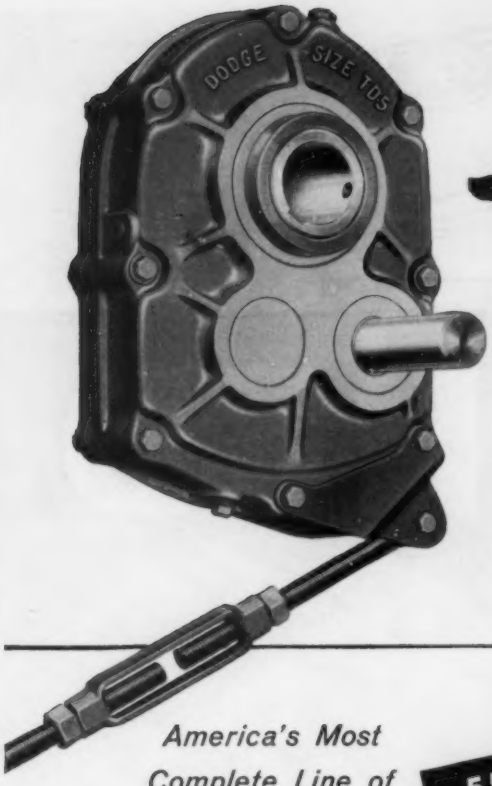
Valley of Precision

For a number of years, Springfield, Vermont, has been my "beat", at least the machine-tool and associated plants there have been. The town is centered in a valley, five miles from the main line of the railroad, and surrounded by high hills that could rather effectively shut out the world. Level ground is at a premium, the streets are narrow and persist in taking off up the nearest hill, and the Black River cuts town and valley into odd-shaped pieces. There's only one commercial hotel and that's a very ancient one fronting on the square. Ancient and modern buildings create a heterogeneous jumble.

But this out-of-the-way town is the home of Jones & Lamson, Fellows Gear Shaper, Bryant Chucking Grinder, and Lovejoy Tool Co. The visitor is promptly confused by their close relationship in spirit, in executive personnel (the same family names keep cropping up), in cooperative effort. They take in each other's washing, so to speak, in research, odd jobs, special machining, general problem solving. Each knows what the other is doing; men of similar title talk over their parallel problems by telephone. Two of the machine-tool builders operate airplanes that fly in visitors, the third charters flights, so there's a steady stream of rather well-known names in Metalworking stopping in. There are research tie-ins with MIT and other institutions. Many of the new ideas in machining practice have been sponsored there—and in social relations, too, for a governor and a US senator have come from there.

Sloan Foundation has apparently been made conscious of all this, because a research grant from that institution, added to a grant by the three machine-tool companies, has made possible a new book by Prof Wayne G. Broehl, Jr, of the Tuck School at Dartmouth. Dr Broehl has made the first full-length business-management study of machine-tool companies, and fleshed it out with general and local historical material and anecdote. The result is a book called "Precision Valley" (Prentice-Hall, Inc, 274 pages, 6 x 9 in., $5.95), just published, that

(Continued on page 159)



Torque-Arm

THE DODGE DEVELOPMENT THAT CHANGED THE NATION'S HABITS OF SPEED REDUCTION

America's Most Complete Line of Shaft Mounted Speed Reducers

55 MODELS

- Capacities up to 170 hp
- Output speeds from 10 to 378 rpm!
- Single Reduction
- Double Reduction
- 5 to 1 Ratio
- 15 to 1 Ratio
- 25 to 1 Ratio
- Any speed ratio up to 150 to 1 obtainable by selection of pre-determined combination of reducer and V-belt drive.

CALL THE TRANSMISSIONEER—your local Dodge Distributor. Factory trained by Dodge, he can give you valuable help on new, cost-saving methods. Look in the *white* pages of your telephone directory for "Dodge Transmissioneer."

In fewer than ten years, the range of Torque-Arm Shaft Mounted Speed Reducers has increased from 6 to 55 models, to meet the ever increasing demand for this improved method of speed reduction.

By eliminating foundation, sliding base and flexible coupling this modern speed reducer has saved untold installation time and untold dollars of cost.

The rugged semisteel housing developed by Dodge has never been improved upon. It is corrosion resistant—and it has the strength to hold bearing seats in line for the life of the unit.

Dodge design provides wide spacing for the bearings. Loads are carried easily, contributing to Torque-Arm's long life and very high efficiency. The gears are finest quality—helical, heat treated steel.

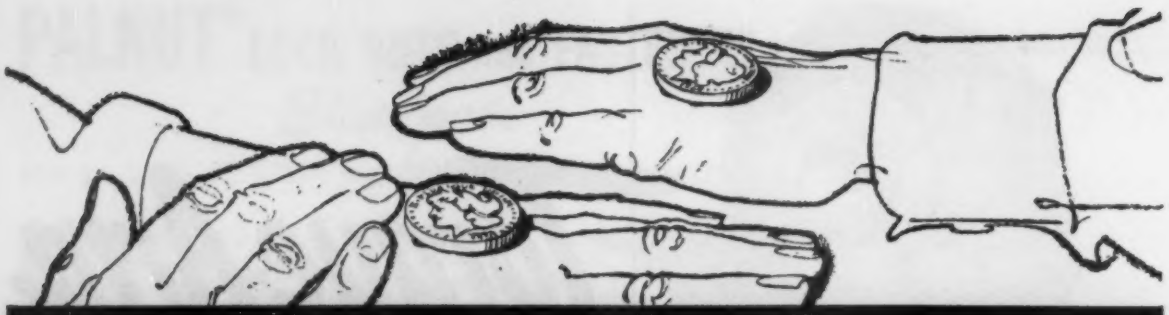
Torque-Arm mounts vertically or horizontally in any position around the driven shaft. It locks to the shaft on *both* sides of the housing. The holes in the output hub provide simple removal with puller. Overload release and built-in backstop are optional.

Dodge Torque-Arm is America's most widely used shaft mounted speed reducer. It is stocked by your local Dodge Distributor. Ask him. Or write us for bulletin.

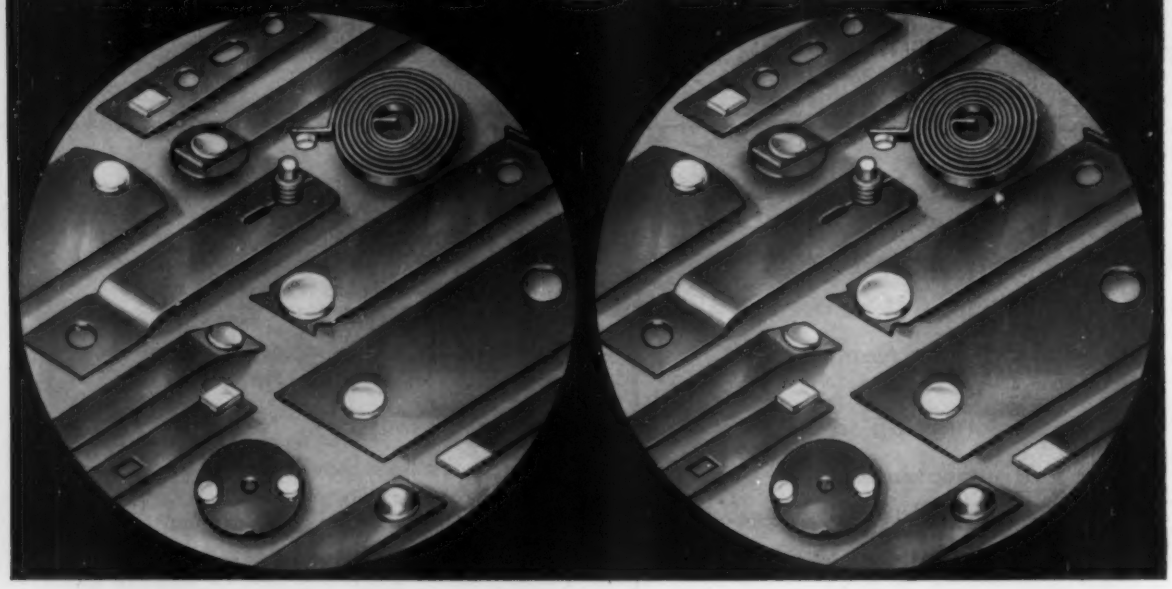
DODGE MANUFACTURING CORPORATION, 1200 Union, Mishawaka, Ind.

DODGE
of Mishawaka, Ind.

CIRCLE 155 ON READER SERVICE CARD



MATCHED



General Plate Guarantees the Performance You Specify with Matched Truflex® Thermostat Metal and Electrical Contact ASSEMBLIES

Here are advantages that are hard to duplicate. *First* . . . clad electrical contacts in any shape or form. *Next* . . . 60 types of Truflex thermostat metal (resistivity from 15 to 850 ohms per c.m.f.) to meet every requirement.

But most important at General Plate complete units are fabricated according to your specifications. Shipped to you ready for application in your product, these assemblies eliminate your fabricating headaches. Experimental and assembly adjustment costs are crossed from your books. You save money, time, worry and trouble.

Design engineers are invited to make use of General Plate contact and thermostat metal engineering services . . . for materials selection . . . parts design . . . samples. Send us a drawing of one of your bimetal-contact parts and let us show you how General Plate Truflex Thermostat Metal and Electrical Contact assemblies can be put to work for you. Write:

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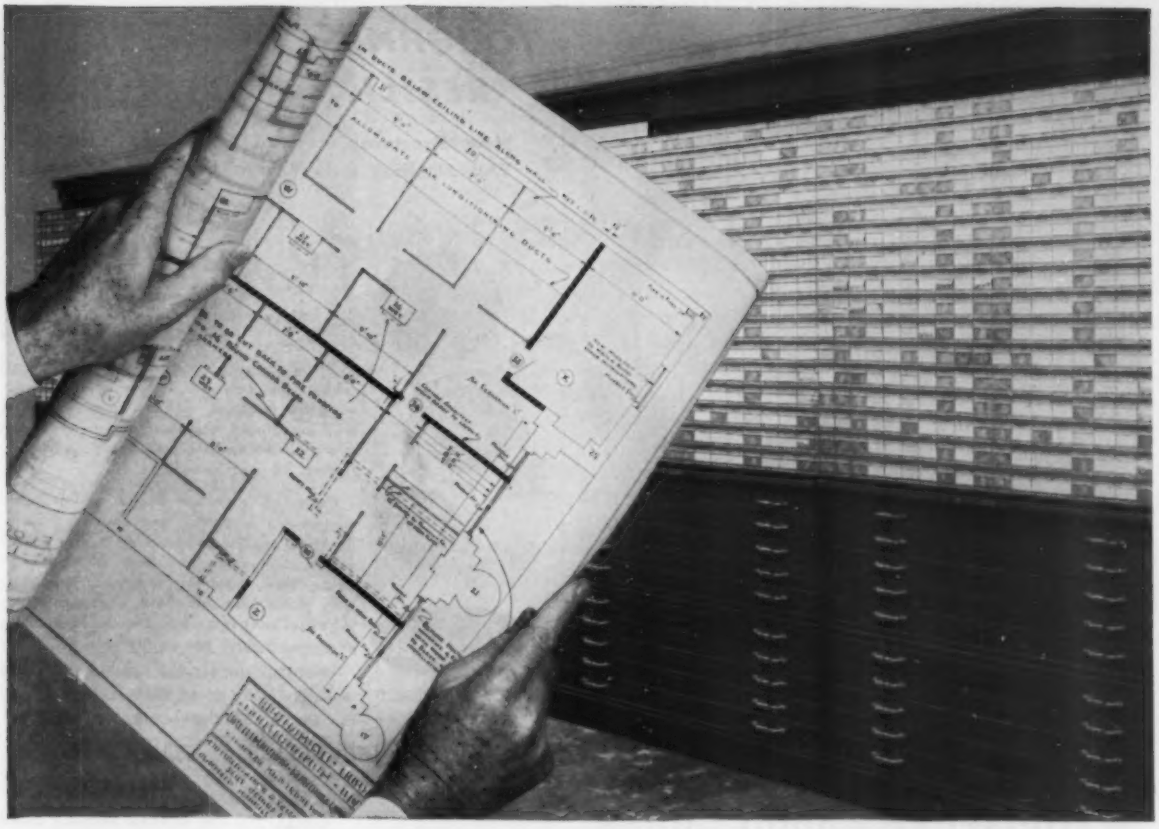

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Safeguard your investment in costly originals with durable drafting films of Du Pont MYLAR®

Your valuable original drawings resist slow deterioration, tearing and rough handling when you use drafting film made of Du Pont "Mylar"* polyester film. That's because the base—"Mylar"—is tough and durable . . . won't dry out or become embrittled with age. "Mylar" is flexible, stable . . . resists absorption of moisture.

Drafting film of "Mylar" provides good contrast for microfilming . . . makes paper intermediates unnecessary. Because it costs less than many grades of tracing cloth, drafting film of "Mylar" provides you with many new cost saving opportunities.

So next time you order, ask for pencil and ink drafting films of "Mylar". . . *safeguard your investment* in drafting time and labor.

If you would like samples for testing, we will ask manufacturers of drafting film of "Mylar" to send you a sample. Write E. I. du Pont de Nemours & Co. (Inc.), Film Dept., Room P-11, Wilmington 98, Delaware.

*"Mylar" is Du Pont's registered trademark for its brand of polyester film.

"Mylar" resists absorption of moisture and liquids due to accidental spillage.

"Mylar" provides extra protection against tearing . . . has good fold endurance.

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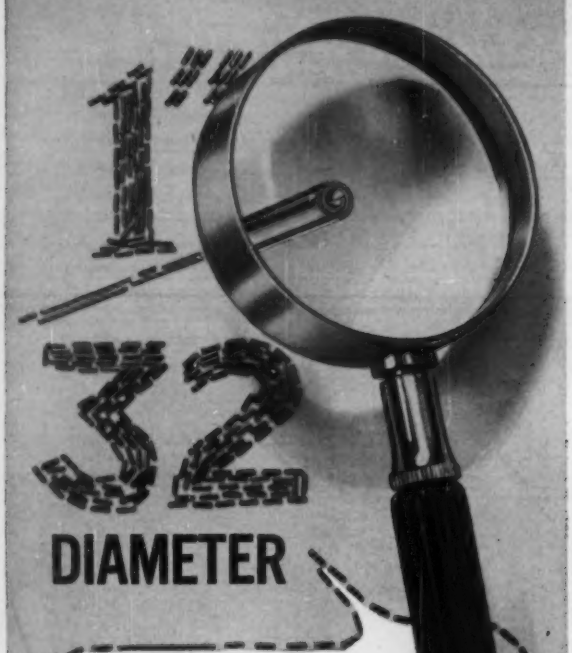
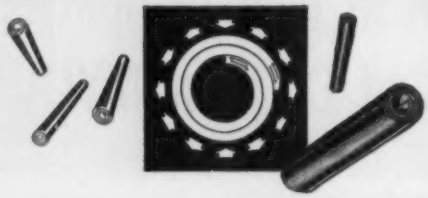
This fraction is made of 237 actual size 1/32" Spirol pins:



Flexible - Yet Stronger - Because

MINIATURE SPIROL PINS HAVE TRUE SPRING COILS



See that spirally coiled cross-section above? Picture it in a pin only 1/32" in diameter, and you have the reason why only SPIROL pins can be made strong enough to withstand stress and shock in miniature sizes. When inserted in the hole, SPIROL pin tension is distributed evenly all around — no stress concentration at any point. Because this unique 360° radial tension eliminates flexing failure, miniature SPIROL pins can be made in NON-HEAT-TREATED NICKEL STAINLESS STEEL, as well as chrome stainless steel, hardened and tempered. Spiral cross-section permits wide plus-and-minus hole tolerances, eliminating precision drilling. Stock diameters: 1/32"-.039"-3/64"-.052". Other stock diameters: 1/16" to 3/4".

FREE! *Write for complete literature and price list on SPIROL spring pins.*

SPIROL *the true spring* **PIN**

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New Structural Material Combines Hardness With Elasticity to Resist Wear and Flex Fatigue

ElastaCAST URETHANE RUBBER

Giving up to ten times the wearability of rubber, this new structural material has remarkable abilities of combining hardness with exceptional toughness, durability, tensile strength; and resistance to abrasion, friction, flexing, oil and grease.

ElastaCAST's broad range of desirable engineering properties and unusual versatility offers product engineers the key to radical design changes in the industrial equipment field. Now, hardness, toughness and elasticity can be combined to overcome countless problem and trouble areas in component performance and service life.

Acushnet PRECISION-MOLDED RUBBER PRODUCTS

Precision-cast to your specifications. Not available in liquid or uncured form. Send for ElastaCAST Engineering Notebook.

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Eonic is regularly supplying Landing Gear, Drum, Pump, Face, Cylindrical two and three dimensional Cams to manufacturers throughout the world.

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CIRCLE 211 ON READER SERVICE CARD

No. 7 of a series

Eastman 910 Adhesive solves another production bottleneck

Cinaudagraph, Inc. of Chicago, Illinois, manufactures radio and television speakers.

By switching from soldering to bonding with fast-setting, high-strength Eastman 910 Adhesive, Cinaudagraph eliminated a bottleneck in the assembly of a 2¾ inch speaker for portable transistor radios.

The adhesive bonds the pole tip to the magnet and the pole tip-magnet assembly to the speaker yoke, with excellent magnetic continuity.

The adhesive has been used successfully on more than 100,000 speakers. *Material costs were reduced 25%—labor costs, 50%.*

Eastman 910 Adhesive is making possible faster, more economical assembly-line operations and new design approaches for many products. It is ideal where extreme speed of setting is important, or where design requirements involve joining small surfaces, complex mechanical fasteners or heat-sensitive elements.

Eastman 910 Adhesive is simple to use. No mixing, heat or pressure is required. Upon spreading into a thin film between two surfaces, setting begins immediately. With most materials, strong bonds are made in minutes.

What production or design problem can this unique adhesive solve for you?

For a trial quantity (⅓-oz.) send five dollars to Armstrong Cork Co., Industrial Adhesives Div., 9111 Irvin Street, Lancaster, Pa., or to Eastman Chemical Products, Inc., Chemicals Div., Dept. P-11, Kingsport, Tenn. (Not for drug use)

CIRCLE 212 ON READER SERVICE CARD

combines the picture at Springfield with that of the industry and the nation generally.

I found it fascinating, despite Dr Broehl's addiction to the phrase "machine toolers" (meaning machine-tool builders), and some occasional over- or under-detail. He has loaded the book with comparative tables, so an engineer interested in management gets a quick picture, even of profit, dividends and such, year by year. The figures alone show the steady increase in importance of this town, from 1.3 to 2.4% of Vermont population (1909-54), from 3.0 to 5.3% of machine-tool industry sales, but from 1.6 to 16.3% of Vermont production, helping to move this industry from eighth place to first in Vermont. The industry there employs over 12% of the people, and pays over 18% of the state total.

Springfield was founded in 1761, got its first machine-tool plant in 1888 by buying Jones & Lamson, a struggling 60-year-old company at Windsor, about 17 miles away, and moving it in. This was the first new plant in the town for years, and it actually stopped a steady decline in population. The purchase was made by a group of local business men with tax relief from the town. Fellows and Bryant both grew out of J & L, because the latter was committed to a one-product policy. Its executives in each case suggested that an engineer with a different machine in mind start his own company, and in each case invested in the venture.

Springfield actually provides a cap-

(Continued on page 162)

"I call it a wheelbarrow—but there seems to be something missing."

HIGH SPEED, Sensitive Polarized RELAYS

"DIAMOND H"

SERIES P Relays

For electronic and communications applications

Engineered to provide extremely fast action with high sensitivity, freedom from bounce and excellent stability, "Diamond H" Series P Polarized Relays give consistent performance with low distortion. Under some conditions they will handle over 1,000 pulses per second.

Magnetically latched SPDT, with two independent coils, Series P Relays are available with various coil resistances from 10 to 4,000 ohms each coil. Contact ratings will vary with switching speeds desired, but range from 60 milliamperes to 2 amperes.

Extremely compact, to save space and weight, they fit standard octal sockets. Their impact and vibration resistance is excellent for relays of this type, thanks to extra-rugged construction.

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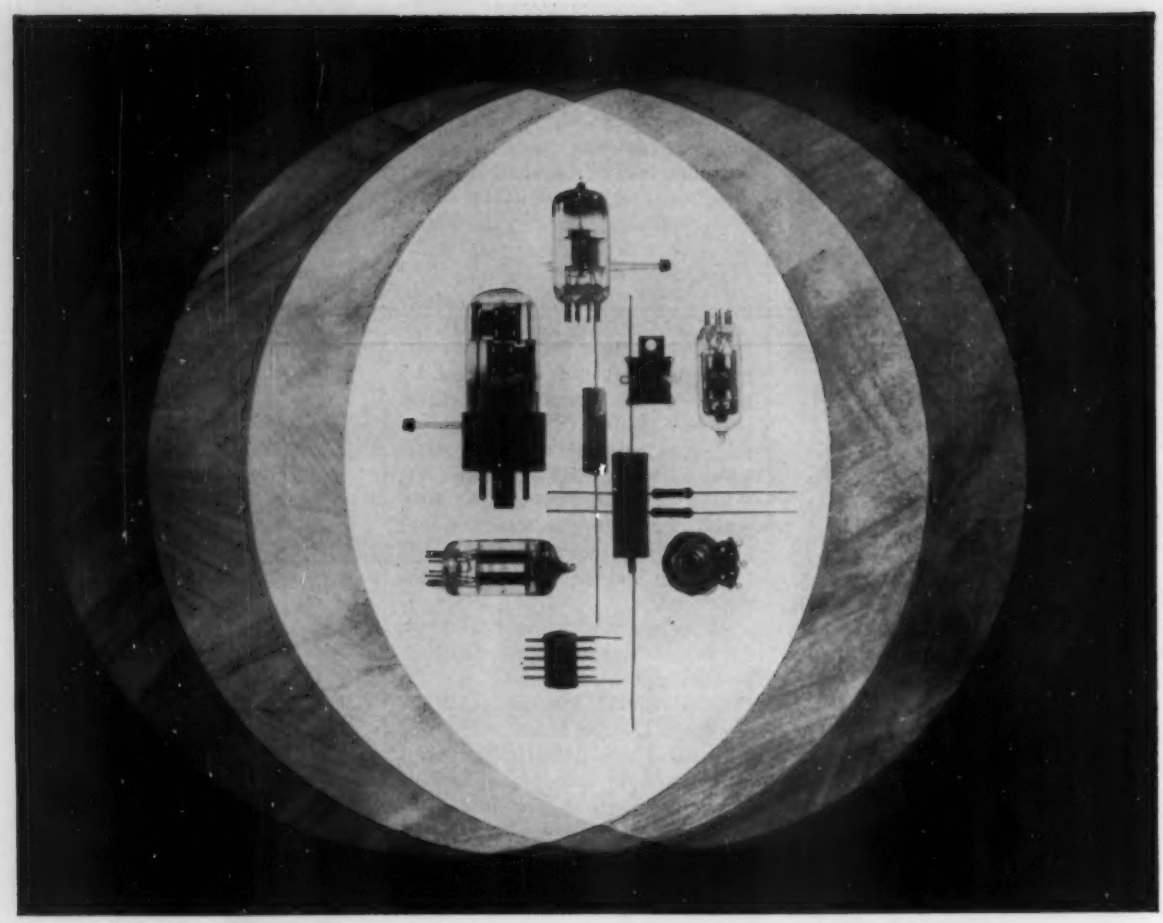
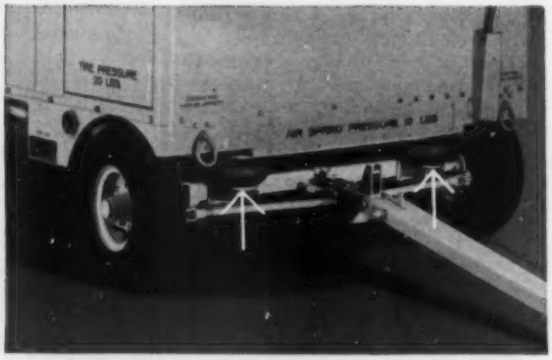


How to take the danger out of delicate moves

Firestone Airmounts protect jet bomber field-test unit from shock in American Air Filter Company's (Defense Products Division) electronic trailer

Transporting a trailer filled with sensitive electronic equipment for testing jet bomber systems demands effective isolation of shock under all weather and terrain conditions. Human lives may depend on how well these units are isolated from jolts and jars of field use. Huge investments in aircraft also weigh heavily in the balance. To meet these exacting suspension requirements, American Air Filter Company (Defense Products Division) selected Firestone Airmounts.

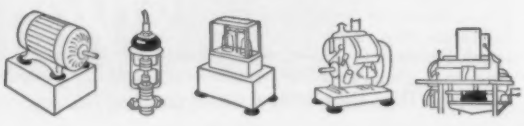
Firestone Airmounts—the same type air springs so widely used in trucks, trains, buses and automobiles—are answering an increased variety of shock, vibration, suspension and actuation problems in industry. They're used on stationary as well as mobile equipment. Why not write us for a low-cost, long-term solution for *your* vibration problems. Discover how Firestone Airmounts offer you a proved, simplified way to increase efficiency and protect your property and products.



In addition to suspending wheels, Firestone Airmount is used as shock absorbing element in the towbar for maximum protection of electronic equipment.

FIRESTONE **airmount**

Firestone Industrial Products Co., Noblesville, Indiana

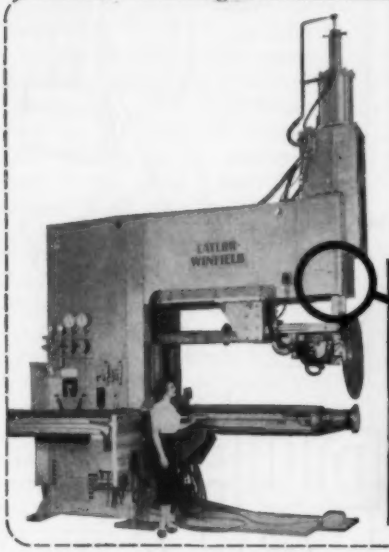


BEARING TIPS
by McGill

McGILL *CAMROL*® bearings cost less to increase efficiency of cam follower, guide and support roller applications

Using CAMROL CF and CYR (cam yoke roller) bearings eliminates the inconvenience of obtaining and processing component parts for built up followers. It costs less to select the proper size CAMROL bearing from stock than machine and assemble loose bolts, bushings, bearings, and snap rings.

CAMROL bearings are engineered and precision built to carry heavier loads with greater accuracy and alignment. An extra heavy outer race with full roller complement on a flanged stud (or inner for CYR) offers high load and shock capacity. Smooth, dependable action with low starting friction is assured through longer machine life. Available sealed also.



Improved performance, reduced friction and greater accuracy as ram guides in huge welder

The long ram stroke and large diameter welding wheel impose severe requirements on the CAMROL equipped ram guiding device of this resistance seam welder manufactured by the TAYLOR-WINFIELD CORPORATION.

The CAMROLS provide greater accuracy with less friction than was experienced with a round ram and bushing type bearing formerly used. Lubrication is simplified, maintenance reduced and performance is excellent.

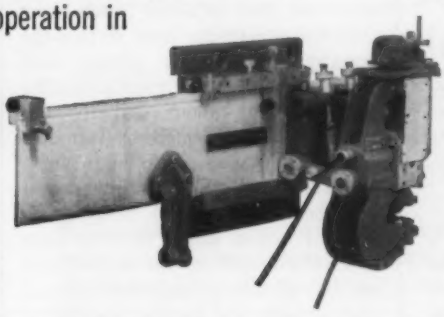
The welder has a throat depth of 84" and a 12" vertical stroke of the upper ram carrying the large diameter welding wheel.

CAMROL® bearings take severe impact loads in hydraulic snubbing hooks

CAMROL CF bearings are used as hook positioner rollers in BYRON JACKSON HYDRAPLEX HOOKS. These heavy-duty (500 ton capacities) hooks are used in oil well drilling work. The hook positioner mechanism includes CAMROL cam followers that travel on a hardened cam track when the load is released to return the hook to its original position. The CAMROL bearings take severe impact loads in the thousands of pounds.

Ease of assembly and smooth operation in electrolimit continuous gage

PRATT & WHITNEY CO., INC., manufacturers of the ELECTROLIMIT CONTINUOUS GAGE shown here have cut costs through the elimination of built up followers requiring ball bearings, shafts, spacers and milling slots by using sealed CAMROL bearings. They are prelubricated and protected. The CAMROL bearings which travel along a vertical cross slide rail, provide smooth, easy action as the gage slides onto strip material running through the mill. No bearing replacement reported in over 10 years.



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McGILL®

precision needle roller bearings

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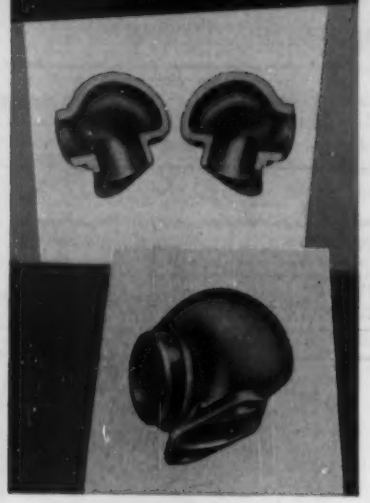
McGILL MANUFACTURING COMPANY, INC., BEARING DIV., 201 N. LAFAYETTE ST., VALPARAISO, INDIANA

two halves *don't* make a hole!



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We don't tackle casting problems halfway at Hitchiner.

Here's a cross section where the inside dimensions are greater than the holes. Originally made in sections and assembled — now the whole unit is precision cast and is lighter and stronger.

Where application requirements demand that a part be of intricate shape; of unusual contour, of fine detail, or, of metals difficult or impossible to machine — investment casting provides an efficient and economical solution.

Only your production costs are cut in half when you utilize the efficiency of investment casting. You save time and plenty of labor. And . . . you'll have a wide selection of metals; the non-ferrous group, the carbon and low alloy steels, the hard-to-form, hard to machine high alloy steels . . . even cobalt base alloys.

For complete details, see this new illustrated, informative booklet on the art of Investment Casting. It could be the best investment you ever made.

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sule picture of the growth of the machine-tool industry, as well as of the decline and resurrection of New England industry. Superficially, it is just a typical town, but a little checking shows it to be quite unusual. James Hartness, of comparator fame, and one-time governor, wanted to get away from people at times. So he put a catacomb of rooms under his front lawn, leading to a 10-in telescope, the first in this country oriented with star precession, so only one movement keeps the scope on a star. The catacomb is now a very unusual cocktail bar (his house is a top-quality small hotel sponsored by the three machine-tool builders). I got my first sight of the rings of Saturn, with the 'scope operated by his granddaughter.

To get freight in and out, Springfield built a 6-mile railroad which still operates, although it no longer carries passengers and most of the freight now moves by truck. It has a foundry cooperatively operated by the machine-tool builders like the hilltop Hartness House. It has some of the oldest, as well as some of the newest, factory buildings in the country. The oldest of these date back before 1888, but house both modern shops and modern ideas.

One graphic illustration of the unusual cooperativeness and energy in the town was the combined machine-tool show put on by the Springfield companies with Cone Automatic of Windsor back in 1947. That was a tough year, as Dr Broehl points out, so the companies decided to do a little bootstrap pulling. When I was there, the town—and adjacent hotels—were jammed with visitors from all over the country. I remember talking with three Detroit master mechanics who were worrying about seniority and racial problems created by introduction of southern white and Negro labor during World War II. And over at Chester Inn, seven miles away, where I had to stay, I met two men in a bar who gave me the first inklings of the revolution beginning in machinery feeds and speeds. That led to a series of articles on high-speed machining which upset many diehard oldsters far removed from Springfield.

It was at Springfield, too, where I learned first of the problems involved in high-precision measurement. There were performed experiments on inac-

(Continued on page 163)

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Tangents .....**continued**

curacies of gage-block stacks, temperature variations, and like thorny subjects produced by measuring to millionths. It was there, too, that I got my first schooling in what later came to be known as numerical control, in simplified dynamometers, in high-finish internal grinding, in electronic precision gaging, and in the design problems associated with rotational speeds of 40,000 to 200,000 rpm.

The latter development created some first-class headaches. High-precision anti-friction bearings burned out at 40,000 rpm; the higher their precision, the faster they burned out. The trouble was finally found to be retainers, and the cause to be the fact that a shaft at 40,000 rpm and above is in reality a gyro; it rotates about its own center of gravity, so it fights the bearing. Its own, and the bearing's slight inaccuracies make trouble. The solution proved to be sloppy bearings.

Further, a ⅛-hp high-frequency motor stores enormous amounts of energy at high speed. I tried to stall one—and found that the completely smooth ¼-in.-dia shaft would burn its way through a 1 x 2-in. stick as efficiently as a circular saw.

Reminiscences flood deep and fast through any one who has been to Springfield, and Dr Broehl has awakened some I thought were long since forgotten. A lobster feed one night at the Hitormis Club (a skeet club sponsored by Fellows executives), a trout-fishing orgy one cold day at a private club, serious technical discussions between tables in the Hartness bar or dining room . . . it's quite a town! —EJT

"You can stop designing that now, Figby—we've already built it!"

NYLASINT bearings in overhead sliding door hanger outwear roller bearings 5 to 1, prevent galvanic corrosion and corrosive wear.

NYLASINT® sintered nylon parts have permanent "built-in" lubrication and exceptionally long wear resistance

- NYLASINT parts deliver all the prime advantages of nylon plus the additional and important properties of the inorganic additives that make up the NYLASINT formulation.

Fillers such as molybdenum disulphide or graphite are alloyed with crystalline nylon powders to produce cost-saving parts for applications such as these:

- where continuous low starting and running friction is necessary and applied lubrication is impractical.
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- where bearing loads are high and PV's (load in psi X velocity in Ft./min.) are well beyond the capacity of regular nylon.
- where improved wear over molded nylon is necessary to make parts functional.
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Cold pressing and oil sintering is accomplished by economical mass production. Parts are processed with minimum internal strains, uniform shrinkage, accurate profiles, no degating and no flash lines.

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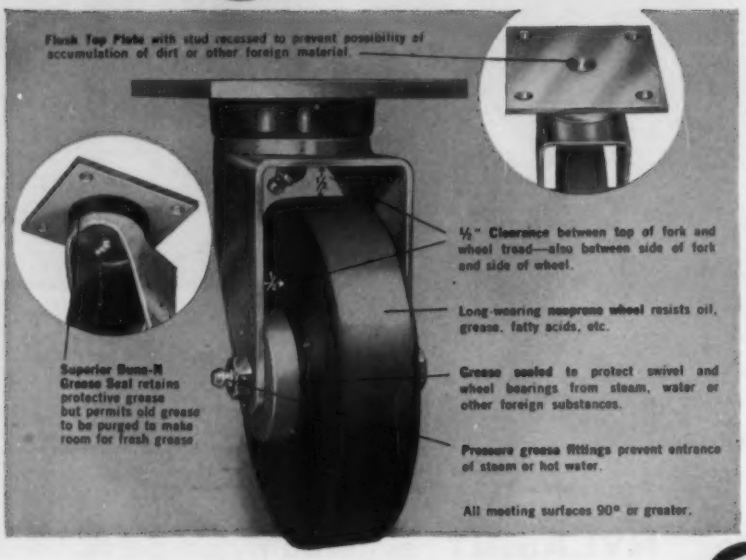
RESISTS CORROSION

J&J Grease Seal Caster


Flush Top Plate with stud recessed to prevent possibility of accumulation of dirt or other foreign material.
½" Clearance between top of fork and wheel tread—also between side of fork and side of wheel.
Long-wearing neoprene wheel resists oil, grease, fatty acids, etc.
Superior Buna-N Grease Seal retains protective grease but permits old grease to be purged to make room for fresh grease
Grease sealed to protect swivel and wheel bearings from steam, water or other foreign substances.
Pressure grease fittings prevent entrance of steam or hot water.
All meeting surfaces 90° or greater.

. . . designed to the exacting specifications of the Bakery Industry Sanitation Standards Committee

Grease sealed throughout to protect the swivel and wheel bearings from wet floor conditions or the effects of steam or hot water cleaning. Pressure grease fittings prevent entrance of moisture, dirt, lint, etc. Long wearing "neoprene" wheel resists oil, grease, and fatty acids. Easy to clean, with wide wheel clearances. Designed for 200# (per caster) load area. Top plate is standard 4″ x 4″ with 3″ x 3″ hole spacing.

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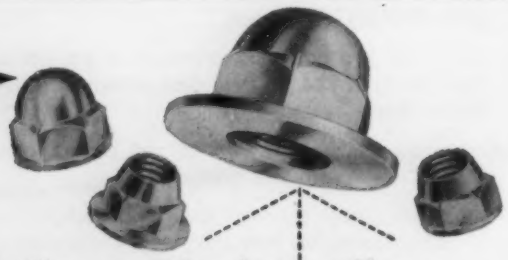
GRC idea



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Standard thread sizes from No. 4 through ½"—14 hex sizes.

- **Rustproof and corrosion resistant**
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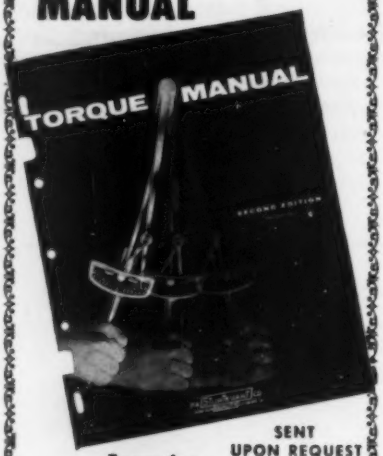
"TORQUE WRENCH" MANUAL



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CIRCLE 164 ON READER SERVICE CARD

DESIGN ABSTRACTS

Engineering Management

Planning and control problem areas of engineering management are discussed and objectives and methods for improvement are described. Among the topics covered are responsibilities of management, information systems, managing as a cyclic process, review and feedback, performance measurement, communications, utilization of manpower, scheduling.

"Planning and Control in Engineering Management", N.J. Ream, Lockheed Aircraft Corp. ASME paper 59-MGT-7. ASME, 29 W 39th St, New York 18.

Consolidation of Distributed Masses

By considering the mass of a body as if it were concentrated at two or more points in space, the solution of static and dynamic balancing problems may be appreciably shortened. Dealing first with centers of gravity and moments and products of inertia, the principle of substitute masses is extended to problems of deflections and vibrations.

"The Consolidation of Distributed Masses," W. H. Sheppard. Mechanical World and Engineering Record, 31 King St W, Manchester 3, England.

Gear Materials

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"Evaluation of Gear Materials Scoring at 700 F", Jackson, Muench, Scott, General Electric Co. American Society of Lubrication Engineers paper 591C-6, 5 N Wabash Ave, Chicago 2, Ill.

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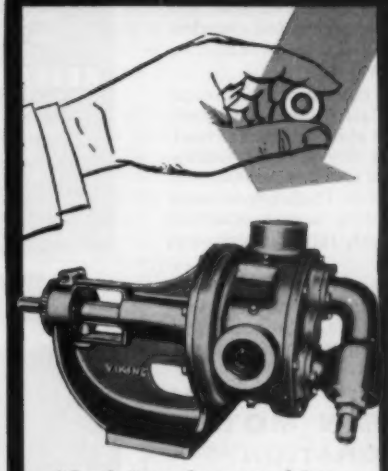

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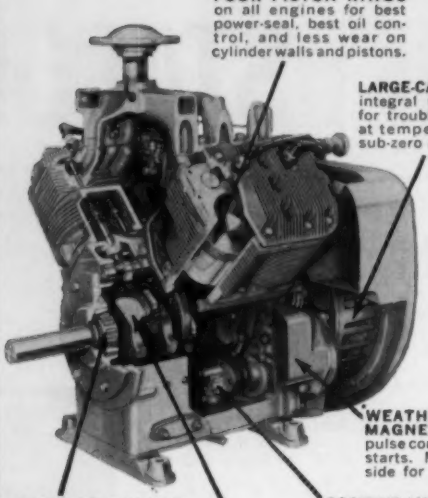
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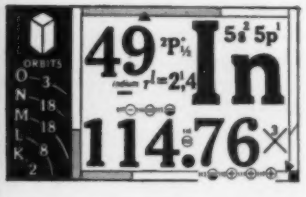

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are described, arrangement of courses into departments is discussed and means of implementing the program are briefly noted.

"A Program in Engineering Sciences for All Engineering Students", A. T. Murphy, University of Wichita. Electrical Engineering, Oct 1959, AIEE, 33 W 39 St, New York 18.

Synchronous Motor Torques Defined

Six commonly used terms for types of torque (rated load, locked rotor, accelerating, pull-in, reluctance, pull-out) are defined and each is discussed. Effects of various factors on torque are illustrated with curves. Synchronous Motor Torques Defined", R. C. Morse, Allis-Chalmers Electrical Review, 3rd Quarter, 1959, Milwaukee 1, Wis.

Bearings, Lubricants and Lubrication

An annotated listing of 277 papers delivered during 1958 is presented under the following categories: fluid film bearings, ball and roller bearings, friction and wear, automotive lubricants, metalworking lubrication, lubricant properties. A bibliography of these papers is broken down in a similar manner.

"Bearings, Lubricants and Lubrication—A Digest of 1958 Literature", by Elwell, Lewis, Shugarts, et al. Mechanical Engineering, Oct 1959, ASME, 29 W 39 St, New York 18.

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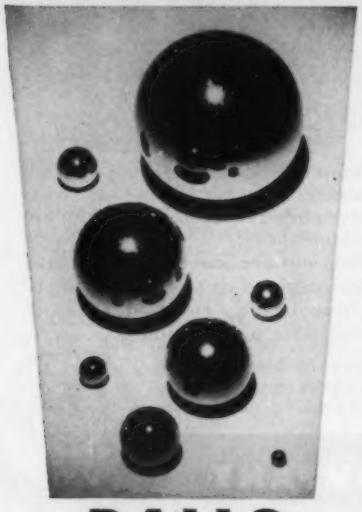

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DOUGLAS M WARSCHAUER, Aeronautical Research Laboratory, Wright Air Development Center. McGraw-Hill Book Co, Inc, 330 W 42nd St, New York 36. 5½ x 8½, 267 pp. $6.50.

This intermediate-level text describes the physical principles underlying the behavior of semiconductors, transistors, and other solid-state devices, as well as their application in circuits. Calculus is not used in presenting the concepts. There is valuable material on growth and purification of semiconductors, fabrication of transistors, and theory of nontransistor devices such as thermistors and phosphors. Quantitative problems illustrate and expand the text. A selected bibliography, tables of physical constants, properties of silicon and germanium, a periodic table and a table of radiation wavelengths are at the end.

Scientific Russian

GEORGE E CONDOYANNIS, Associate Professor Modern Languages, St Peter's College. John Wiley & Sons, Inc, 440 Fourth Ave, New York 16. 5½ x 6¾ (spiral bound), 225 pp. $3.50.

Subtitled "A concise description of the structural elements of scientific and technical Russian," this book is designed to be used almost from the beginning as an adjunct to the reading of scientific and engineering material—together with a dictionary.

Digital and Sampled-Data Control Systems

JULIUS T TOU, Associate Professor of Electrical Engineering, Purdue University. McGraw-Hill Book Co, Inc, 330 W 42nd St, New York 36. 6 x 9¼, 631 pp. $15.

Derived from material previously available only in technical journals and conference proceedings, this book gives basic theory and available techniques for the analysis and design of digital and sampled-data control systems and related problems. It is largely the outgrowth of a set of lecture notes, first prepared in 1956, for a two-semester course offered by the author to graduate students at the Moore School of the University

(Continued on page 171)

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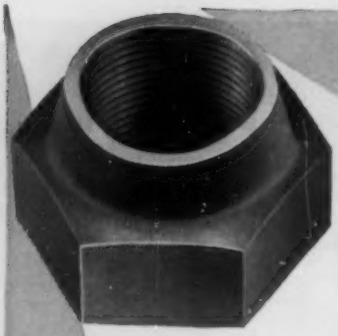

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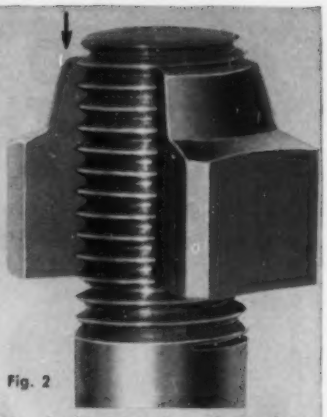

Fig. 2

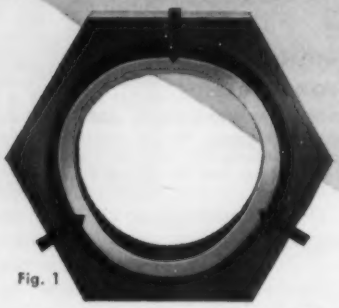

Fig. 1

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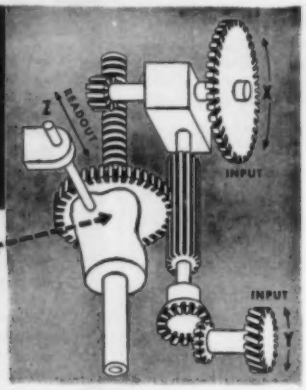

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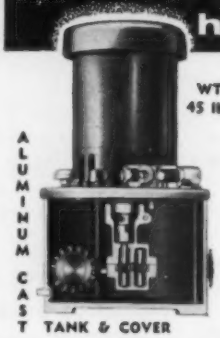

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1½	88	177	265	353	131
2	157	314	471	628	73

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of Pennsylvania. An adequate preparation in an introductory course on feedback control systems and a sound knowledge of Laplace transforms and complex variable theory is assumed. Many numerical examples and over 70 problems clarify development of theory and illustrate the methods. There is also a fairly extensive table of z transforms and modified z transforms.

Research Techniques in Human Engineering

ALPHONSE CHAPANIS, Professor of Psychology and Industrial Engineering, Johns Hopkins University. Johns Hopkins University Press, Homewood, Baltimore 18, Md. 6¼ x 9¼, 316 pp. $6.

Along with describing some of the methods available for collecting trustworthy data on men and machines and the relationships between them, this book discusses some of the principles and guide line normally employed in such studies. Techniques and examples (both good and bad) are drawn from a number of fields, including industrial engineering, psychology, anthropometry, physiology and statistics.

Based on a monograph entitled. "The Design and Conduct of Human Engineering Studies", and published by the author in 1956, the present volume is intended for the engineer or supervisor responsible for the design and operation of machines and systems. Such topics as methods of direct observation, the study of acci-

(Continued on page 173)

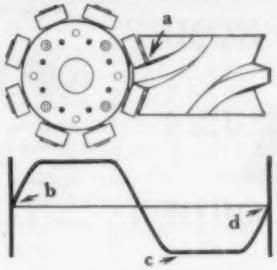
"You've got a great idea here, Fred. It should make me a cool million."

DESIGN CONSIDERATIONS

Critical Points in Acceleration Characteristics of Indexing Devices

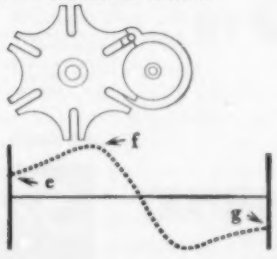
Maximum speeds of production machines are frequently affected by performance limitations of their indexing mechanisms. The efficiency of the indexing mechanism, itself, is dependent upon the amount of shock, vibration and other dynamic forces involved in the starting, stopping and rate of change from maximum acceleration to maximum deceleration.

FIG. 1 · · FERGUSON DRIVE



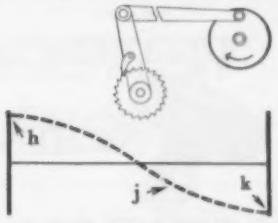
The acceleration curves of such mechanisms provide a graphic means of evaluating and comparing dynamic conditions that affect the performance of the indexing device and the machine. The Ferguson Drive in Fig. 1 is a cam indexing mechanism employing preloaded bearing followers rolling along a tapered cam rib. Two followers are in contact with the rib at all times (a) maintaining a zero backlash condition and an accuracy of .001″ without auxiliary locating devices. This Drive features a modified trapezoid acceleration characteristic . . . a combined cycloidal and gravity curve. The Ferguson Drive has an initial force of zero (b) and a smooth, sinusoidal increase. Its maximum acceleration value (c) is very low and the change through maximum deceleration to zero (d) is gradual. These smooth indexing characteristics of the Ferguson Drive permit operation of production machinery at speeds as high as 2,000 RPM, if necessary, with a minimum of 8,000 hours operation while maintaining extreme precision and zero backlash.

FIG. 2 · · GENEVA DRIVE



The six-stop geneva drive shown in Fig. 2 is representative of the geneva family in that its dynamic forces are instantaneously applied and the initial acceleration force is fairly high (e) with an even higher maximum acceleration (f). The change to maximum deceleration is gradual but there is an almost instantaneous stop (g). When operated at high speeds, geneva drives wear out quickly and cause heavy vibrations that seriously affect the life of the machine and product quality.

FIG. 3 · · RATCHET & CRANK



The rachet and crank has a distorted cosine acceleration curve (a true cosine curve is illustrated in Fig. 3) with an extremely high initial acceleration (h). The descent to maximum deceleration (j) is gradual but, as with the geneva drive, stopping is instantaneous (k). Even with auxiliary braking action, overtravel is extreme and accuracy is very poor. Rachet and crank devices have very limited use in modern production machines.

FIG. 4 · ·

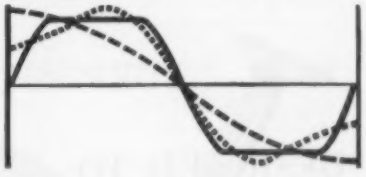


Fig. 4 shows the curves of the three mechanisms on the same diagram. Note that only the Ferguson Drive has an initial force of zero and the lowest maximum acceleration value combined with a gradual change to maximum deceleration. *This is why the Ferguson Drive does what no other indexing device can do!*

• SEND FOR CATALOG

Complete information about the Ferguson Drive is available in the form of an easy-to-use catalog containing load ratings and dimensions of many standard units, drawings and installation photos. There is a copy for every design engineer . . . for your copy write: **Ferguson Machine Corp., 7818 Maplewood Industrial Court, St. Louis 17, Missouri.**

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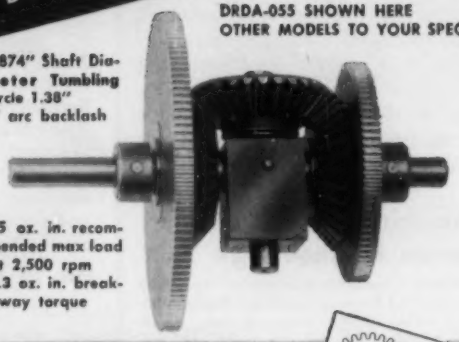

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0.3 oz. in. breakaway torque

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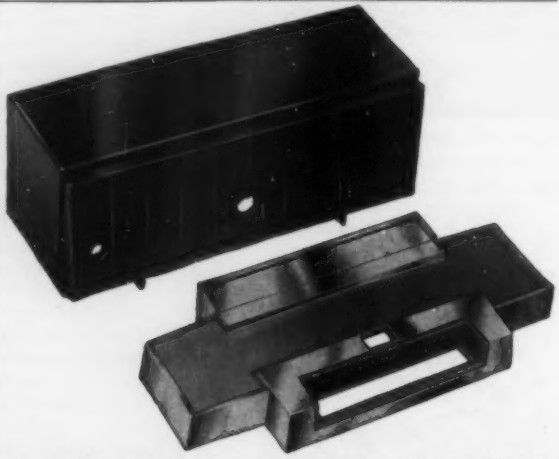

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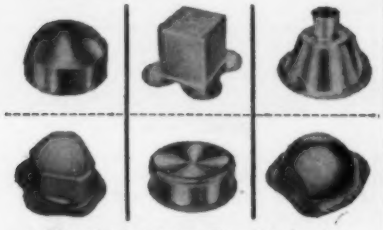

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dents and near accidents, statistical methods, experimental technique, psychophysical methods, and articulation testing form some of the book's chapters.

Servomechanism Fundamentals

BEN ZEINES, RCA Institutes, Inc, and Hofstra College. McGraw-Hill Book Co, Inc, 330 W 42nd St, New York 36. 5¾ x 9¾, 257 pp. $5.50.

This brief, elementary text has been written especially for the technician. It covers basic methods of servo systems and data transmission systems, and assumes reader is primarily concerned with operation and maintenance. Block diagrams show basic components common to all servo systems. Letter symbols, abbreviations and symbols used for circuit and system diagrams have been selected in general to conform to the adopted or recommended systems of the IRE and ASME.

Typical topics are: servo motors, performance improvers and measurement. Questions or problems accompany each chapter.

Magnetism and Magnetic Materials

OSBORN, BROOKS, CALLEN, GOLDMAN, KRUMHANSL. McGraw-Hill Book Co, Inc, 330 W 42nd St, New York 36. 7½ x 10¾, 323 pp. $10.

This volume, ("Proceedings of the Fourth Conference on Magnetism and Magnetic Materials") consists of papers presented at the Conference in Philadelphia, Nov 17-20, 1958. This event was sponsored by the Magnetics Subcommittee of the AIEE Committee on Basic Sciences, with the cooperation of the American Physical Society, American Institute of Mining, Metallurgical and Petroleum Engineers, and the Office of Naval Research.

Prepared as a supplement to the Journal of Applied Physics, Vol 30, 1959, the more than 240 papers, written by over 350 specialists in the field, bring together recent contributions under the broad headings of ferrites; computer components; macromagnetics: domain walls, magnetic properties of metals and alloys, fine particles; amplifiers; microwave applications; resonance; metallurgical considerations; fundamental interac-

(Continued on page 174)

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tions; instrumentation; thin films; neutron diffraction and irradiation; garnets and other compounds; anisotropy—other than in thin films.

Frequency Response for Process Control

Edited by CALDWELL, COON, AND ZOSS. McGraw-Hill Book Co, Inc, 330 W 42nd St, New York 36. 6¼ x 9¼, 393 pp. $11.50.

Given are fundamental methods of frequency response and their application to the analysis, testing, and design of process control systems, with typical solutions to many practical problems. Topics covered are: distance-velocity lag, linear lag, stability, analysis, damped response, closed-loop response, disturbances, system time constants, dynamics of temperature measurement, pneumatic transmission lines, cascaded systems, and technique for converting from step to frequency response using a desk calculator.

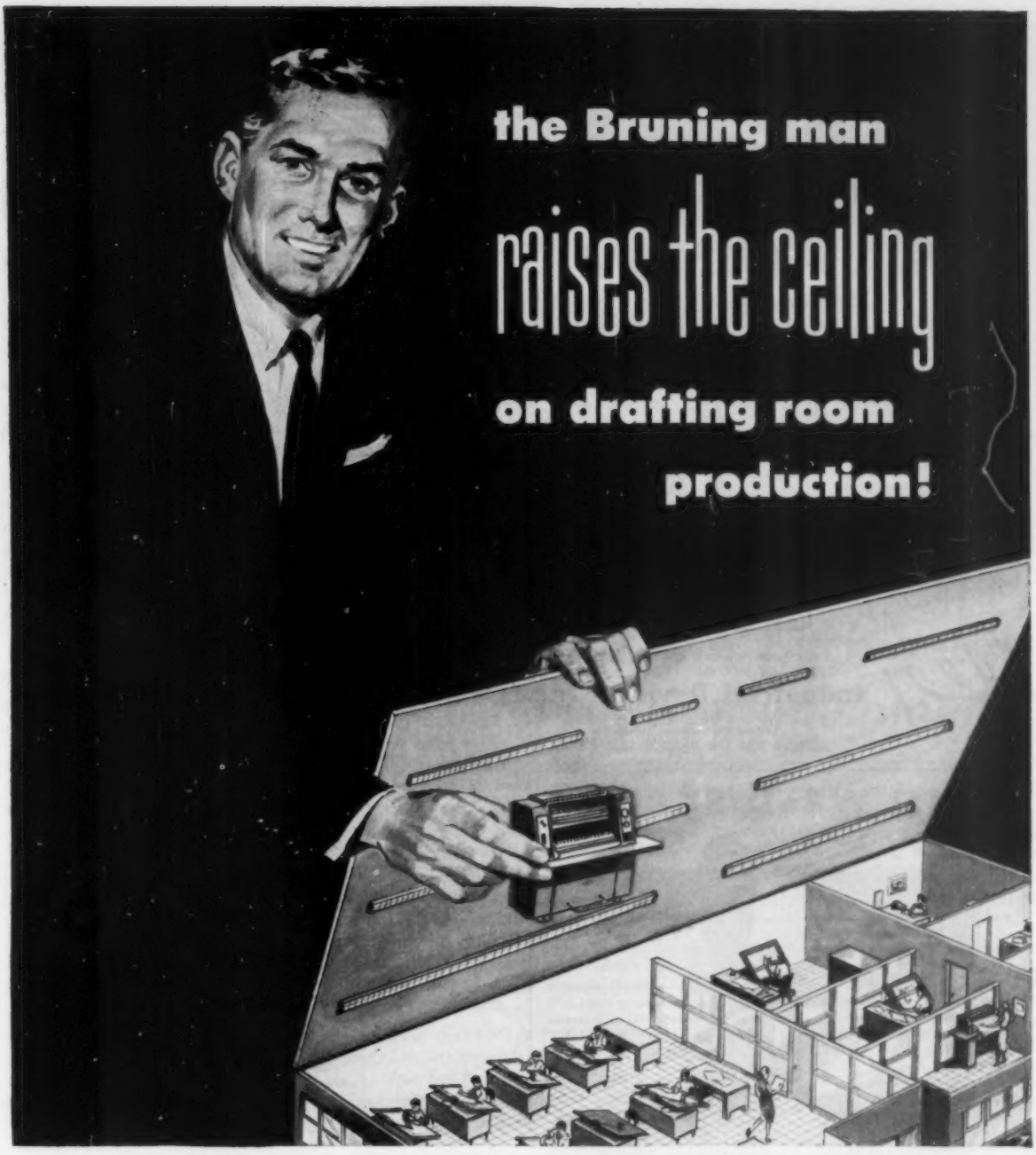
Machinery's Handbook

E OBERG, F D JONES. Industrial Press, 93 Worth St, New York 13. 5 x 7½, 2104 pp. $11.

The Machinery's Handbook has been one of the standard references for design in the mechanical field. In this edition, besides, the more familiar features in the earlier editions, it contains more data on recently revised engineering standards both American and British. New sections have been added giving stress calculations and tables for curved beams as used in machine frames, round plates, cylinders, tubes and

(Continued on page 177)

"For him, it brings out his best—"



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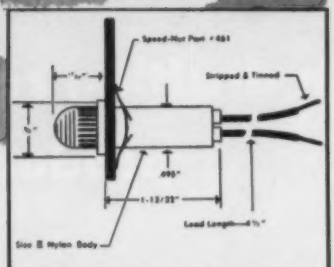

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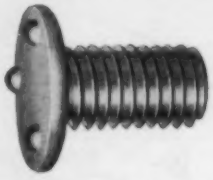
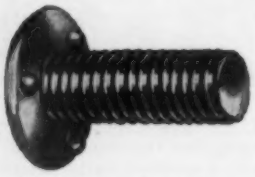


GW SCREWS — Used where design requires a smooth unmarred surface and a fastener permanently fixed in place.

HH SCREWS — Used where a single, button-type projection is required when welding to curved surfaces, to heavy sheet 3/32" or thicker, or to ends of rods.

RW SCREWS — Used where a hermetic seal is required to prevent leakage of air, gas, water, oil or dust, or when welding to perforated metal or wires.



HW SCREWS — Used where a Self-locating through bolt is required to be fixed securely in place so that it will not turn and a flush surface is required for attaching mating parts.

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shells. Another added feature is the section of ball, roller and needle bearings based on dimensions, fit and performance.

However, any book requires a year or more between the time it is prepared and the time it is published. Therefore, one part of it is already outdated. In this handbook, the inch-to-meter conversion is based on one inch = 25.40005 mm. On July 1, the standard inch was changed to 25.4 mm. (*See PE—Jan 19, p 16; English-speaking Nations Adopt New Pound and Yard Standards*). But this conversion is such a small portion that it does not impair the book's usefulness. It is very useful and well worth its price, if you don't already have one.

Other Books of Interest

Atomic Power and Energy Resource Planning.
RICHARD A. TYBOUT. Bureau of Business Research, Ohio State University, Columbus, Ohio. 6 x 9, 98 pp, $2.
Brings together latest information on world energy resources and needs.

Properties of Rare Earth Metals and Compounds.
Battelle Memorial Institute, 505 King Ave, Columbus 1, Ohio. 9 x 11, 214 pp, $10.

Problems in Engineering Drawing: Fourth Edition.
WARREN J LUZADDER. Prentice-Hall, Inc, 70 Fifth Ave, New York 11. 8½ x 11, 80 pp, $3.95.
A series of worksheets in the form of partial layouts, used for instruction in basic drawing and engineering drawing courses.

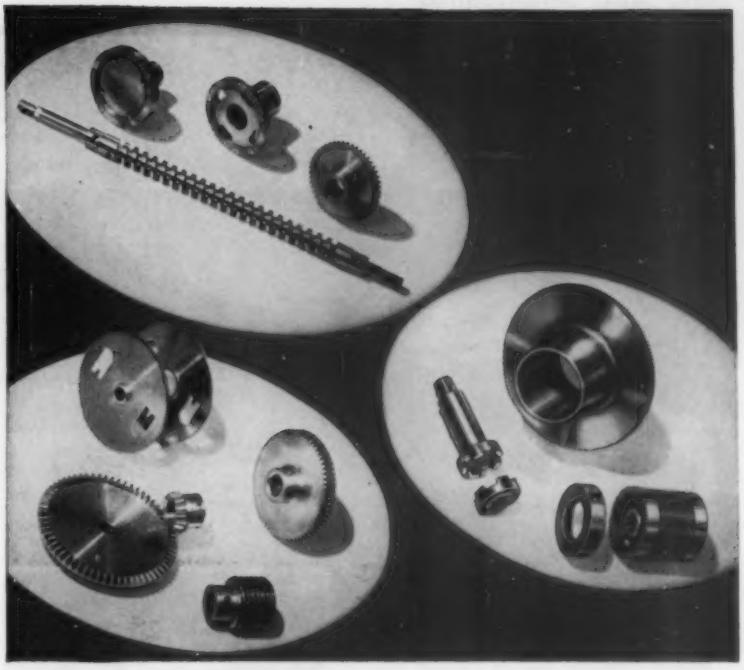
1958 Proceedings: American Society for Testing Materials.
American Society for Testing Materials, 1916 Race St, Philadelphia 3. 6 x 9, 1430 pp, $12.

Injection and Combustion of Liquid Fuels.
PB 131008, PUTNAM, BENINGTON, EINBINDER et al. Office of Technical Services, Dept of Commerce, Washington 25, DC. 8¼ x 11, about 1000 pp, $9.

Proceedings of Fifth International Conference on Hot Dip Galvanizing.
Zinc Development Assn, 34 Berkeley Square, London W1, England. 6 x 10, 355 pp, $8.80.

Report of Conference on Kinetics of High-temperature Processes.
Edited by W. D. Kingery. John Wiley & Sons, Inc, 440 Fourth Ave, New York 16, NY. 8 x 11, 326 pp, $13.50.
Discusses imperfections and diffusion in nonmetals, diffusion in liquids and liquid-solid re-

(Continued on page 179)



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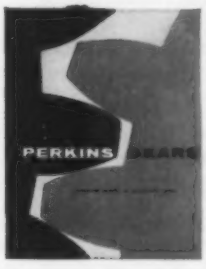

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ASA Standard B5.4-1959. American Standards Assn, 70 E 45th St, New York 17. 8½ x 11, 48 pp, $2.50.

Unified Miniature Screw Threads.
ASA standard B1.10-1958. American Standards Assn, 70 E 45th St, New York 17. 8½ x 11, 18 pp, $1.50.

Flashtube Data Manual.
Dept 282-LFM, General Electric Co, Cleveland 12, Ohio. 5½ x 8¼, 70 pp, 50¢.
Discusses use of flashtubes in stroboscopic photography.

Current Projects of the American Standards Assn.
American Standards Assn, 70 E. 45th St, New York 77. 8½ x 11, 52 pp. $1.50.

Illustrations for Publication and Projection.
ASA Standard Y15.1-1959. American Standards Assn, 70 E 45th St, New York 17. 8½ x 11, 14 pp, $2.
How to prepare legible and effective illustrations for technical papers and publications.

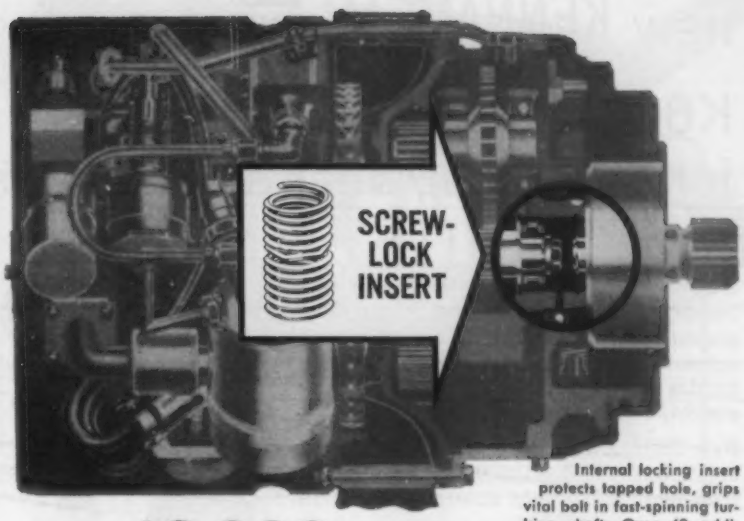
Precision Snap-acting Switches.
NEMA Standard 1C3.1959. National Electrical Manufacturers Assn, 155 E 44th St, New York 17. 8½ x 11, 16 pp, 30¢.

Unfired Pressure Vessels—Section VIII.
American Society of Mechanical Engineers, 29 W 39th St., New York 18. 8 x 11, 212 pp, $6.

Automatic Temperature Controls.
DC3-1959. National Electrical Manufacturers Assn, 155 E 44th St, New York 17. 8½ x 11, 20 pp. 40¢.

Metal Statistics 1959.
American Metal Market, 18 Cliff St, New York 38. 4 x 6, 816 pp, $3.50.

"Yes, Boss, there are two schools of thought on the subject . . . mind if I have one?"



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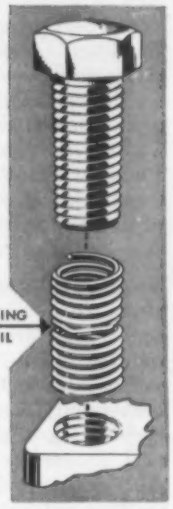

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Index of PRODUCTS ADVERTISED

In This Issue

After reading the advertisements classified below . . . MORE DETAILED INFORMATION about these products can be obtained by using the READER SERVICE CARD.

A

Adhesives 10, 20-21, 112, 136, 159
Aluminum Alloys 54-55

B

Balls 169
Bars
  Nonmetallic 123
Bearings
  Ball 24-25, 114, 152, 161
  Miniature 29
  Needle 161
  Roller .....4th Cover, 24-25, 114, 161
Belts V 20-21
Bi-Metal 156
Blowers 117, 144
Bolts 170
Brake Motors 26-27
Brakes
  Electric 26-27
  Hydraulic 133
  Mechanical 133
  Pneumatic 133

C

Cams 158, 170
Casters 164
Castings 50, 62-63
Castings, Precision Investment . 142, 162
Ceramics 115
Chains
  Conveyor 11
Chemical Treatments 110-111
Closures 143
Clutches
  Electrical .....3rd Cover
  Mechanical 174
Coatings.....10, 96, 110-111
Contacts & Contact Materials..... 156
Controls
  Electrical.....6, 12-13, 109
  Pneumatic 47
Copper & Copper Alloys..... 28
Cork Compositions 31
Couplings
  Hose 130
  Tube 130
Cylinders
  Hydraulic 57, 60, 149
  Pneumatic 57, 60, 149

D

Deep Drawing 172
Die Castings 128-129, 164
Differentials 172
Drafting
  Supplies 61, 157, 165
Drives
  Timing 171
  Variable Speed 11, 125, 183

E

Engines 138, 166
Expanded Metals 153

Index of

PRODUCTS ADVERTISED

In This Issue

F

Fabricated Plastics (see Plastics, Fabricated)
Fabrics 168
Fabrics, Coated 168
Fastening Methods...48, 68, 132, 154, 158 172, 179, 184
Felt 134
Fibre 186
Film, Plastic 43-45
Filters
Hydraulic 111
Fittings, Hose, Pipe & Tube.....130, 145
Flexible Couplings 32, 148
Forgings 50, 113
Furniture, Engrg. Dept..... 165

G

Gaskets 20-21, 31
Gear Motors (see also Motor Reducers) 151
Gears.....14, 131, 172, 177, 181

H

Heating Units 147, 173
Hose & Tubing..... 124

I

Indium 166
Instruments
Electrical 167

L

Lamps, Indicator 182
Laminated Plastics (see Plastics, Laminated)
Latches 132
Liquid Level Controls..... 56
Locks 154
Lubricating Equipment 47, 111

M

Metal Forming 172
Moldings
Plastics (see Plastic Parts)
Powdered Metal (see Powdered Metal Parts)
Rubber (see Rubber Parts)
Motor Reducers (see also Gear Motors) 26-27, 125
Motors, A-C
Fractional 30, 52, 118
Integral.....26-27, 30, 118
Sub-Fractional 146, 151
Motors, D-C
Fractional 30, 52
Integral 26-27, 30
Sub-Fractional 146

N

Nickel Alloys 2
Nuts.....48, 68, 154, 170, 184

P

Packings 20-21, 140
Photographic Equipment
Film.....43-45, 61, 157
Pilot Lights 109, 176
Pins 158
Plastic Parts.....20-21, 123, 163, 172
Plastics.....49, 121-122, 126-127
Plastics, Laminated 186

Continued on p. 182

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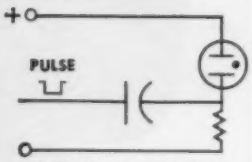
CIRCLE 181 ON READER SERVICE CARD 181

4 ways to use

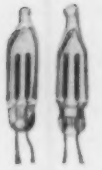
General Electric Glow Lamps as Circuit Components

G-E NE-96 G-E NE-97

1. As a MEMORY DEVICE, because of the differential between starting and operating voltages. Both the General Electric NE-96 and NE-97 are well suited for switching circuits and counters where they can function as transfer elements and as indicators of state or sequence.

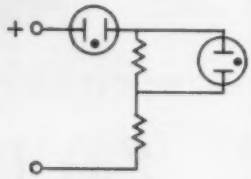


G-E Glow Lamp used in Memory Circuit



G-E NE-76 G-E NE-81

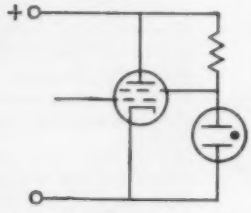
2. As a VOLTAGE INDICATOR, because of their critical starting voltage. The G-E NE-76 and the NE-81 are stabilized and selected for close tolerance on starting voltage. Both find use in gating circuits, logic matrices, switching circuits or as an indicator of input or output levels.



G-E Glow Lamps as Multiple Voltage Indicators

G-E NE-68 G-E NE-80

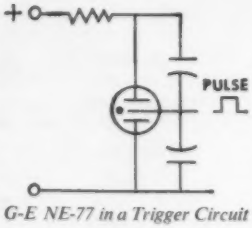
3. As a VOLTAGE REGULATOR, because of their constant operating voltage range. The General Electric NE-68 and its "first cousin", the G-E NE-80 (closer tolerance), function effectively wherever voltage regulation is required. (Glow Lamps for higher current applications are also available.)



G-E Glow Lamp used as a Voltage Regulator

G-E NE-77

4. As a TRIGGERED SWITCH. A low current signal applied to the trigger (third electrode) starts this lamp, permitting conductance of peak current surges up to 100 m.a. in the power circuit. It can be used in counting circuits or as a control device with photocells, thermostats or moisture sensors in trigger circuit.



G-E NE-77 in a Trigger Circuit

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Index of PRODUCTS ADVERTISED

In This Issue

Continued from p. 181

Powdered Metal Parts..20-21, 23, 131, 163
Power Take-Offs 174
Production Machines & Processes.... 151
Production Services (see also Engineering Services) 53
Pulleys 168
Pumps
Air 150
Liquid 165, 170
Vacuum 150

R

Regulators
Pneumatic 47
Relays.....17, 135, 159
Reproduction Equipment 175
Resins 121-122, 126-127
Retaining Rings 15
Rings 50
Rivets 48, 120, 151
Rubber.....53, 58-59, 119, 158
Rubber Parts..2nd Cover, 20-21, 58-59, 158

S

Screws 176
Screw Thread Inserts..... 179
Sealers 10
Seals.....20-21, 139, 140, 162
Servo Controls 183
Shapes, Roll Formed..... 169
Sheaves 150
Sheet, Fabricated 8-9
Sheets
Plastic 123
Silicone Rubber 51, 150
Silicones 33-34
Specialty Fasteners (Pipe Hangers, Special Cold Headed Parts, etc.) ..48 68, 120, 132, 170, 172, 184
Speed Increasers & Reducers..14, 155, 174
Spinning 172
Springs 46, 185
Steel
Alloy.....2, 18-19, 64-67
Coated 18-19
Stainless 18-19, 64-67
Studs 184
Subcontracting Services 8-9
Switches 109

T

Tantalum & Tantalum Alloys..... 180
Thermometers 168
Thermostats 6, 22
Timers 109, 141
Tools 164
Tubing
Plastic 123
Seamless 4, 107
Welded.....4, 8-9, 18-19
Tungsten Carbide 180

V

Valves
Air 1, 60, 95
Hydraulic 47, 60
Solenoid 1, 95
Vibration Dampers
Mechanical 137, 160
Vibration Mountings 137

W

Welding
Nuts 176
Whiteprinting Equipment 175
Wire Cloth 16

INDEX TO ADVERTISERS

This index is published as a convenience to the readers. Every care is taken to make it accurate but PRODUCT ENGINEERING assumes no responsibility for errors or omissions.

Acushnet Process Co. 158
Allen-Bradley Co. 109
Aluminum Co. of America 54-55
Amchem Products, Inc., Metalworking Chemicals Div. 110-111
American Brass Co. 28
Anchor Coupling Co., Inc. 130
Angier Adhesives Div., Interchemical Corp. 136
Armco Steel Corp. 18-19
Armstrong Cork Co. 31
Arwood Precision Casting Corp. 142
Associated Spring Corp. 46
Automatic Switch Co. 135

Babcock & Wilcox Co., Tubular Products Div. 4
Baldwin-Lima-Hamilton Corp., Standard Steel Works Div. 50
Browning Mfg. Co. 168
Bruning Co., Inc., Charles 175

C.E.M. Co. 158
Cambridge Wire Cloth Co. 16
Chicago Rawhide Mfg. Co. ..... 2nd Cover
Commercial Shearing & Stamping Co. 113
Connecticut Hard Rubber Co. 150
Continental Diamond Fibre Co., Subs., Budd Co. 186
Coors Porcelain Co. 115
Crane Packing Co. 140

Dale Products, Inc. 146
Dodge Mfg. Corp. 155
Doehler-Jarvis Div., National Lead Co. 128-129
Dow Corning Corp. 33-34
duPont de Nemours & Co. (Inc.), E. I., Film Dept. 157
duPont de Nemours & Co., (Inc.), E. I., Photo Products Dept. 43-45
duPont de Nemours & Co., (Inc.), E. I., Polychemicals Dept. 121-122
Durametallic Corp. 162
Dynamic Gear Co., Inc. 172

Eastman Chemical Products, Inc., Chemicals Div. 159
Eastman Kodak Co., Recordak Corp., Subs. 61
Eaton Mfg. Co., Dynamatic Div. 97
Eonic, Inc. 158

Fafnir Bearing Co. 152
Fairbanks, Morse & Co., Magneto Div. 146
Fairfield Mfg. Co. 181
Falk Corp. 125
Felters Co. 134
Ferguson Machine Corp. 171
Firestone Rubber & Latex Products Co., Div., Firestone Tire & Rubber Co. 53
Firestone Tire & Rubber Co., Industrial Products Div. 160
Ford Motor Co., Industrial Engine Dept. 138
Fostoria Corp. 146

General Electric Co., Miniature Lamp Dept. 182
General Electric Co., Silicone Products Dept. 51
General Industries Co. 151
Goodrich Co., B. F., Aviation Products Div. 48

(Continued on p. 184)

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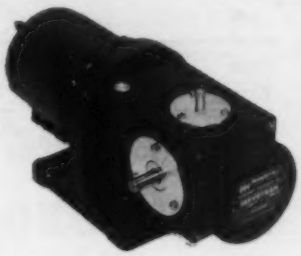

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INDEX TO ADVERTISERS

(Continued from p. 183)

Goodrich, B. F., Industrial Products Co. 112
Grace & Co., W. R., Polymer Chemicals Div. 126-127
Gries Reproducer Corp. 164

Halex Corp., Subsidiary of Polymer Corp. 163
Hanna Engineering Works 104
Hannifin Co., Div., Parker-Hannifin Corp. 95
Hart Mfg. Co. 159
Heli-Coil Corp. 179
Hilliard Corp. 111
Hitchiner Mfg. Co., Inc. 162
Hoover Ball & Bearing Co., Bearing Div. 24-25
Hotwatt, Inc. 173
Humphrey, Inc. 183
Hunter Spring Co. 185

Indium Corp. of America 166
Industrial Devices, Inc. 176
Industrial Tectonics, Inc. 169
Industrial Timer Corp. 141
International Nickel Co., Inc. 2

Jarvis & Jarvis, Inc. 164
Johnson Machine Co., Carlyle ..... 3rd Cover

Kaupp & Sons, C. B. 173
Kennametal, Inc., Metalworking Div. 180
Keystone Carbon Co. 131
Koppers Co., Inc., Plastics Div. 49

Lamb Electric Co. 52
Leach & Garner Co., Industrial Div. 169
Leiman Brothers, Inc. 150
Link-Belt Co. 11, 32
Lord Mfg. Co. 137
Lovejoy Flexible Coupling Co. 148

McGill Mfg. Co., Inc. 161
M-D Blowers, Inc., Subs. of Miehle-Goss-Dexter, Inc. 144
Malleable Castings Council 62-63
Metal & Thermit Corp. 96
Metals & Controls, A Division of Texas Instruments Incorporated 22, 156
Milford Rivet & Machine Co. 151
Miniature Precision Bearings, Inc. 29
Minneapolis-Honeywell Regulator Co., Industrial Div. 56
Minnesota Mining & Mfg. Co., Adhesives, Coatings, Sealers Div. 10
Mobay Chemical Co. 119
Moraine Products Div., General Motors Corp. 23

National Lock Co. 172
National Machine Products Co. 170
National Tube Div., U. S. Steel Corp. 107

Oberdorfer Pump Div., Oberdorfer Foundries, Inc. 170
Ohio Nut & Bolt Co. 176
Ohio Rubber Co. 58-59
Ortman-Miller Machine Co. 149

Palnut Co. 154
Parker-Hannifin Corp., Hannifin Co., Div. 95
Parker-Hartford Corp. 170
Penn Engineering & Mfg. Corp. 184
Penn Metal Co., Inc. 153
Perkins Machine & Gear Co. 177
Petch Mfg. Co. 116
Philadelphia Gear Corp. 14
Precision Rubber Products Corp. 139
Protective Closures Co., Inc. 143

Raybestos-Manhattan, Inc., Manhattan Rubber Div. 20-21
Raybestos-Manhattan, Inc., Packing Div. 20-21
Raybestos-Manhattan, Inc., Plastic Products Div. 20-21
Recordak Corp., Subs., Eastman Kodak Co. 61
Reliance Electric & Engineering Co. 118
Republic Steel Corp. 8-9
Rouland Electric Co. 26-27

INDEX TO ADVERTISERS

Reynolds Metals Co., Industrial Products Div. 102-103
Robertshaw Thermostat Div., Robertshaw-Fulton Controls Co. 6
Rockford Clutch Div., Borg-Warner Corp. 174
Rockwell-Standard Corp., Brake Div. 133
Ross Operating Valve Co. 1

SKF Industries, Inc. 114
Sinko Mfg. & Tool Co. 172
South Chester Corp., Southco Div. 132
Square D Co. 17
Stacor Equipment Co. 165
Standard Steel Works Div., Baldwin-Lima-Hamilton Corp. 50
Stewart Warner Corp., Alemite Div.. 47
Sturtevant Co., P. A. 164

Timken Roller Bearing Co. .....4th Cover
Tinnerman Products, Inc. 68
Titeflex, Inc. 124
Tomkins-Johnson Co. 57
Torrington Mfg. Co., Air Impeller Div. 117
Townsend Co. 120

Union Switch & Signal Div. of Westinghouse Air Brake Co. 167
U. S. Gasket Co., Subs., Garlock Packing Co. 123
U. S. Gauge Div., American Machine & Metals, Inc. 168
U. S. Rubber Co., Mechanical Goods Div. 100
United States Steel Corp. 64-67

Valvair Corp. 60
Viking Pump Co. 165
Vulcan Rubber Products Div., Reeves Bros., Inc. 168

Wagner Electric Corp. 30
Waldes Kohinoor, Inc. 15
Warner Electric Brake & Clutch Co.. 150
Watlow Electric Mfg. Co. 147
Weatherhead Co., The. 145
Westinghouse Electric Corp., Standard Control Div. 12-13
Wisconsin Motor Corp. 166

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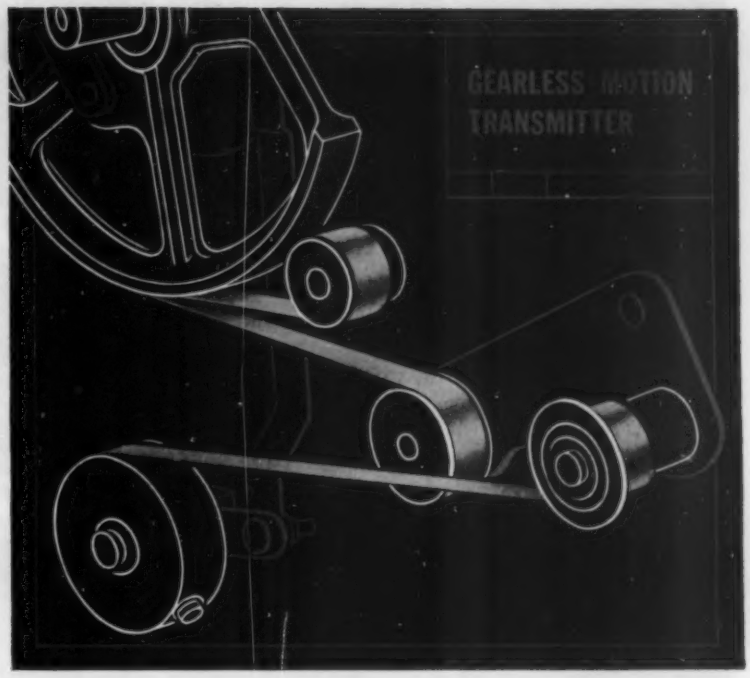
CLASSIFIED ADVERTISING
F. J. Eberle, Business Mgr.
EMPLOYMENT OPPORTUNITIES. . 176, 178
Index to Advertisers begins on P 183
Products Index begins on P 180



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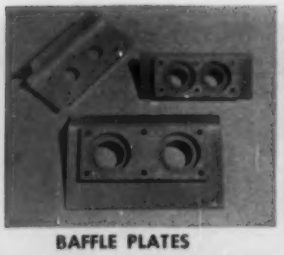

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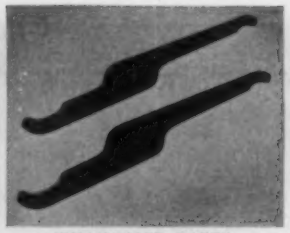

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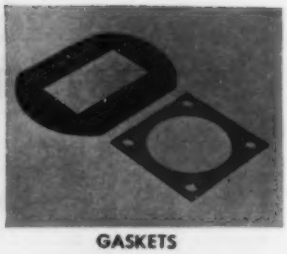

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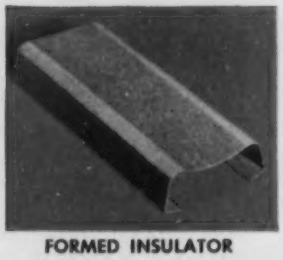

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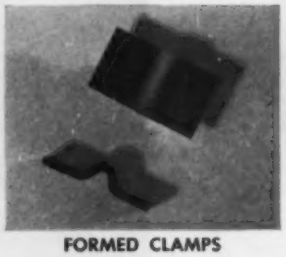

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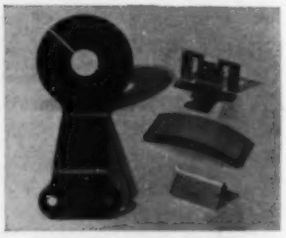
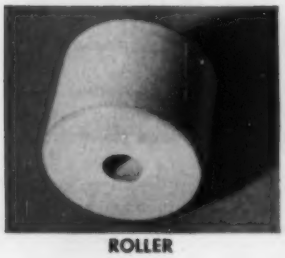


FORMED INSULATORS



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2	22	42	62	82	102	122	142	162	182	202	222	242	262	282	302	317	332	347	362	377
3	23	43	63	83	103	123	143	163	183	203	223	243	263	283	303	318	333	348	363	378
4	24	44	64	84	104	124	144	164	184	204	224	244	264	284	304	319	334	349	364	379
5	25	45	65	85	105	125	145	165	185	205	225	245	265	285	305	320	335	350	365	380
6	26	46	66	86	106	126	146	166	186	206	226	246	266	286	306	321	336	351	366	381
7	27	47	67	87	107	127	147	167	187	207	227	247	267	287	307	322	337	352	367	382
8	28	48	68	88	108	128	148	168	188	208	228	248	268	288	308	323	338	353	368	383
9	29	49	69	89	109	129	149	169	189	209	229	249	269	289	309	324	339	354	369	384
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11	31	51	71	91	111	131	151	171	191	211	231	251	271	291	311	326	341	356	371	386
12	32	52	72	92	112	132	152	172	192	212	232	252	272	292	312	327	342	357	372	387
13	33	53	73	93	113	133	153	173	193	213	233	253	273	293	313	328	343	358	373	388
14	34	54	74	94	114	134	154	174	194	214	234	254	274	294	314	329	344	359	374	389
15	35	55	75	95	115	135	155	175	195	215	235	255	275	295	315	330	345	360	375	390
16	36	56	76	96	116	136	156	176	196	216	236	256	276	296						
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P1	P2	P3	P4	P5	P6	P7	P8	P9	P10
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335—High-strength Belts

MECHANICAL PARTS

301—Double-pedal Floor Lock
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342—Instrument Cabinets

FASTENING AND JOINING

305—Fasteners Have Offset Recess

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310—Size 5 Servo Motor

ELECTRICAL, ELECTRONIC COMPONENTS

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312—Pressure Transducers
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P1	P2	P3	P4	P5	P6	P7	P8	P9	P10
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P11	P12	P13	P14	P15	P16	P17	P18	P19	P20

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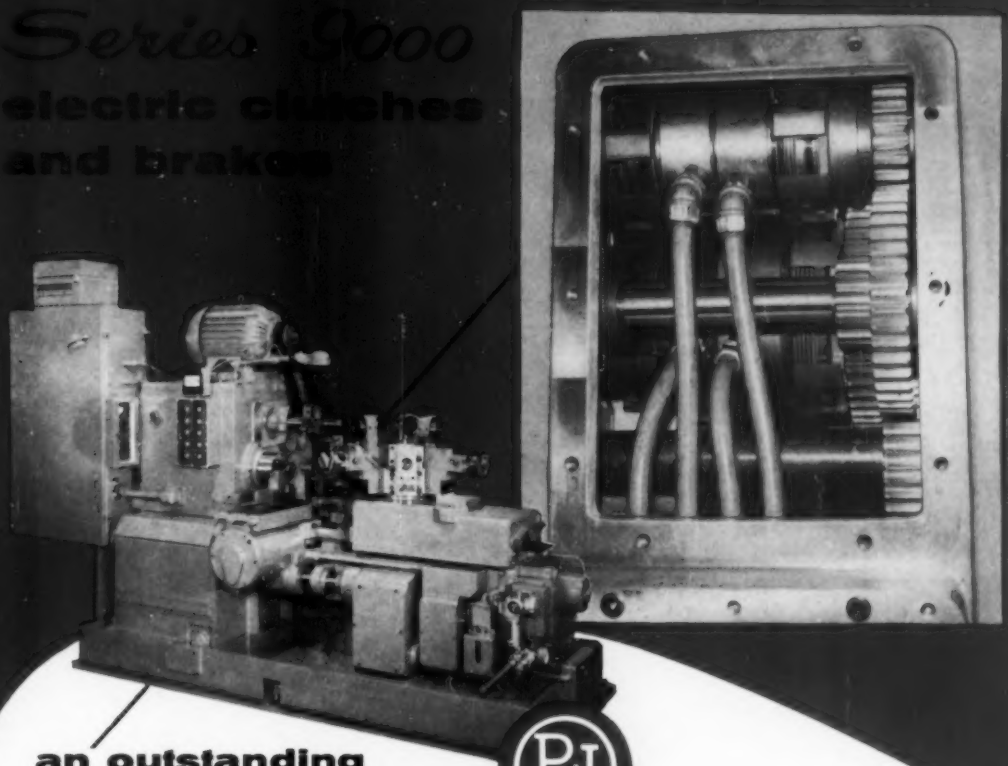

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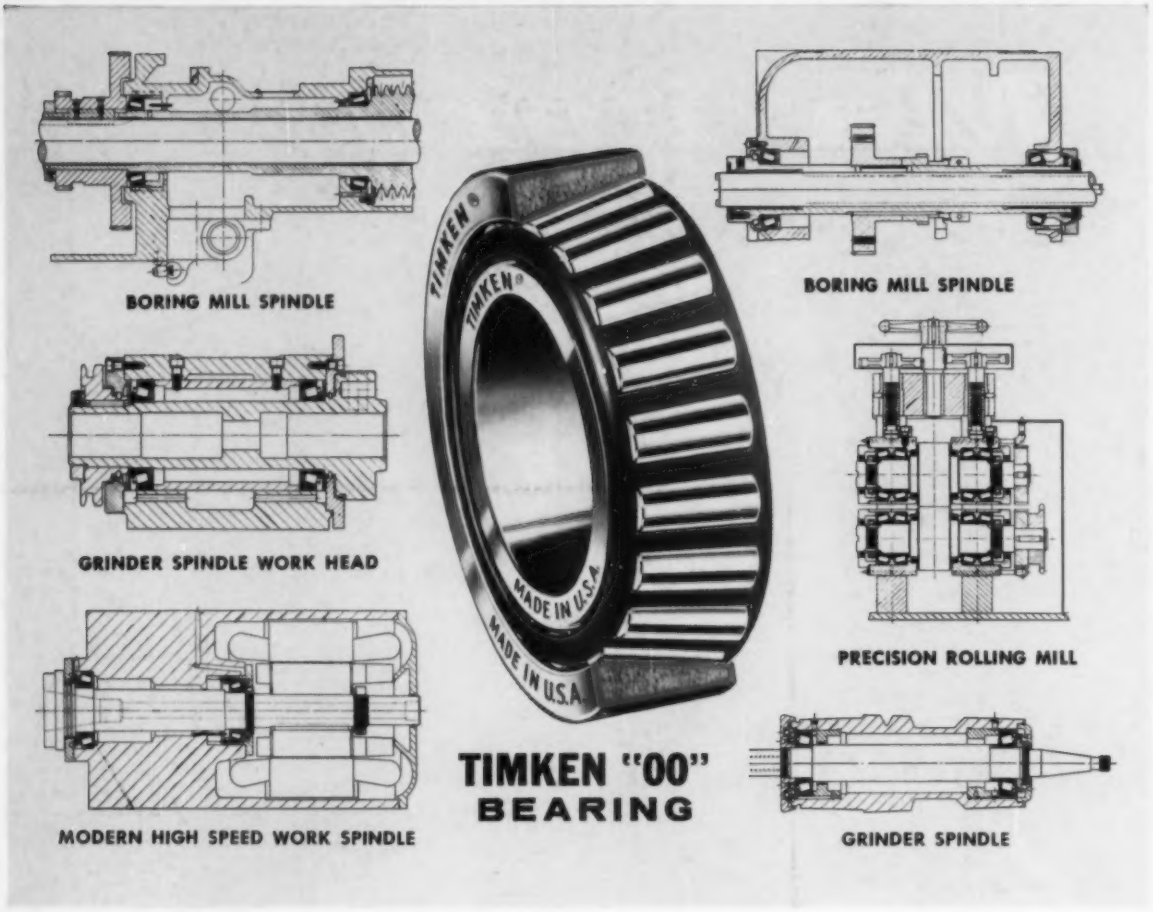

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